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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

QUARTZ CRYSTAL UNIT TEST SET TS-710/TSM

DEPARTMENT OF THE ARMY • MARCH 1956

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful not to contact
high-voltage connections or
115–230-volt input connections
when testing or
servicing this equipment.

DON'T TAKE CHANCES!

EXTREMELY DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Certain points in the power
supply are 540 volts above
ground potential.

TECHNICAL MANUAL No. 11-5106

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *26 March 1956*

QUARTZ CRYSTAL UNIT TEST SET TS-710/TSM

CHAPTER 1
INTRODUCTION

Section I—GENERAL

1. Scope

a. This manual contains instructions covering the installation, operation, maintenance, and repair of Quartz Crystal Unit Set TS–710/TSM (fig. 1).

b. Forward comments on this manual directly to: Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, N. J.

2. Forms and Records

a. Unsatisfactory Equipment Reports. DA Form 468 (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in AR 700–38.

b. Damaged or Improper Shipment. DD Form 6 (Report of Damaged or Improper Shipment) will be filled out and forwarded as prescribed in AR 700–58 (Army); Navy Shipping Guide, Article 1850–4 (Navy); and AFR 71–4 (Air Force).

c. Preventive Maintenance Forms.

(1) DA Form 11–238 (Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form (fig. 7).

(2) DA Form 11–239 (Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form (fig. 8).

Section II. DESCRIPTION AND DATA

3. Purpose and Use

Quartz Crystal Unit Test Set TS–710/TSM is used to measure the series-resonant and antiresonant resistance of quartz crystals in the frequency range of 10 to 1,100 kilocycles for conformance with applicable crystal specifications. Throughout this manual the major component of Quartz Crystal Unit Test Set TS–710/TSM is referred to as the crystal test set.

4. Technical Characteristics

Voltage requirements	115 or 230 volts, 50 to 1,000 cps.
Frequency ranges	Five ranges: 10 to 25 kc, 25 to 70 kc, 70 to 200 kc, 200 to 450 kc, and 450 to 1,100 kc.
Calibration resistors	14 resistors: 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 10,000, 20,000, 50,000, 75,000, 100,000, 125,000, 150,000, and 200,000 ohms.
Calibration potentiometers	Three potentiometers; 0 to 5,000 ohms, 0 to 50,000 ohms, and 0 to 500,000 ohms.
Load capacity	10 to 105 $\mu\mu$f. Dial marked 0 to 100. A calibration chart is supplied with each crystal test set to convert load capacitance in $\mu\mu$f to dial indications.
Dc microammeter	Four scales: one ohmmeter scale, range 0 to infinity; three dc voltage scales, 0 to 5; 0 to 10; and 0 to 25 volts.
Number of tubes	6.

5. Table of Components
(fig. 1)

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Crystal test set	1	10½	19	7	1	32
Accessory box, containing 14 calibration resistors, 3 calibration potentiometers (par. 4), and 2 crystal adapters (fig. 2).	1	6¾	5¾	2⅛	0. 1	2
Cord CG–433A/U	1	60 (long).				
Cord CX–112/U	1	72 (long).				
Calibration chart	1	11	8			
Running spares (par. 7)	1 set.					

Note. This list is for general information only. See appropriate supply publications for information pertaining to requisitioning of spare parts. Refer to paragraph 8 for a list of additional equipment required but not supplied.

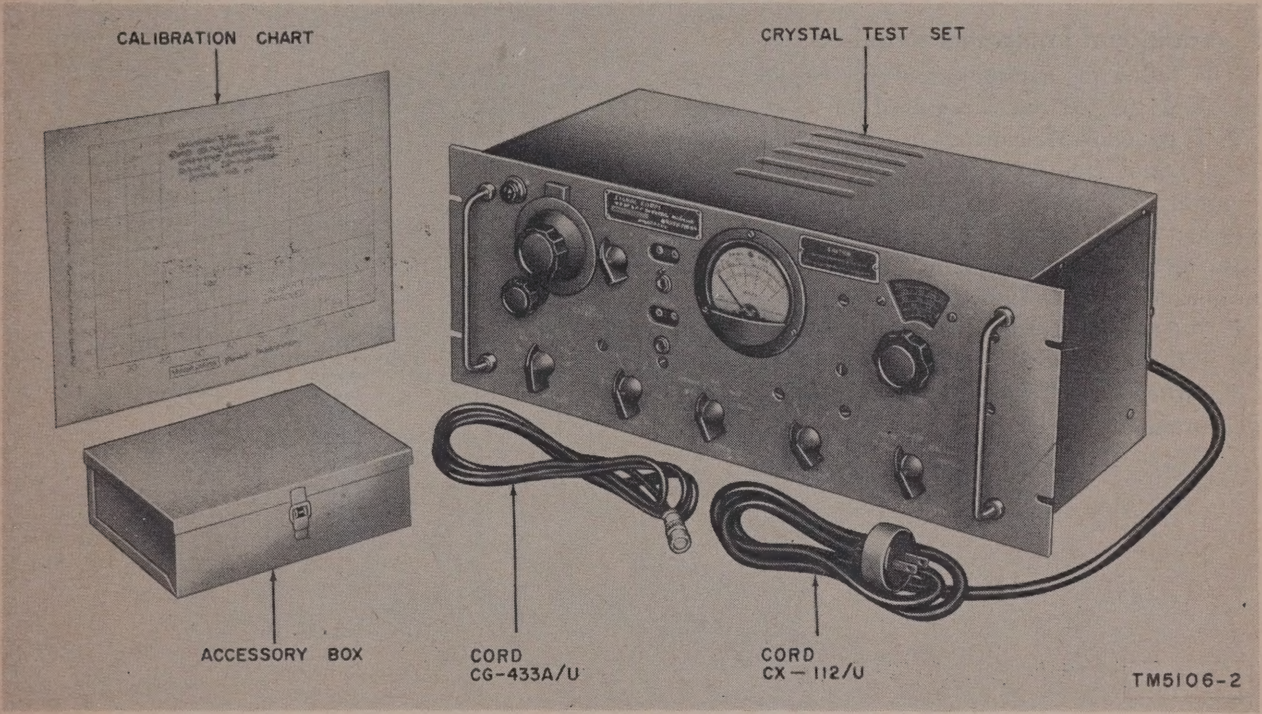


Figure 1. Quartz Crystal Unit Test Set TS–710/TSM, components.

6. Description of Components

a. Major Component. The crystal test set (fig. 1) is a panel chassis assembly inclosed in a metal case designed for rack mounting. Ventilating louvers are located on the top and back of the case. Operating controls are located on the front and rear (fig. 5).

b. Minor Components. The following components are supplied with the crystal test set.

(1) *Accessory box.* The accessory box (fig. 2) is a metal, hinged case with a latch. The box contains three calibration potentiometers, 14 calibration resistors, and two crystal adapters.

(2) *Cord CX–112/U.* This cord (fig. 1) is a 6-foot power cord with a female connector at the equipment end and a male connector at the other end.

(3) *Cord CG–433A/U.* This cord is a 5-foot radio-frequency (rf) pickup cable assembly with a Plug UG–88/U at one end.

(4) *Calibration chart.* This chart contains information required to convert load capacitance in micromicrofarads ($\mu\mu f$) into LOAD CAPACITY dial readings.

7. Running Spares

Following is a list of running spares for the crystal test set. These items are shipped inside the equipment.

5 fuses, 2-ampere.
1 tube, 5Y3W (par. 40).
1 tube, 6AQ5W.
1 tube, 6BA6W.
1 tube, 12AX7.
1 tube, OA2.
1 tube, OB2.
1 pilot lamp, bayonet base.
1 indicator lens, red.

Note. This list is for general information only. See SIG 7 & 8 TS-710/TSM for information pertaining to allowable spare parts.

8. Additional Equipment Required

The following equipment is not supplied with the TS-710/TSM but is required for its operation.

a. Frequency Measuring Group OA-484/FSM-3 (fig. 3) and frequency Calibrator FR-70/U are required for measuring the frequency of the crystals being tested. Refer to the publication covering Quartz Crystal Unit Test Set AN/FSM-3 for detailed information on these equipments.

b. A 0 to 500 microampere meter is required for use if the meter on the crystal test set goes off scale when making a frequency and resistance measurement.

c. A plug, such as the PJ-055, and a 2-wire cord are required to connect the 0 to 500 microampere meter to the crystal test set.

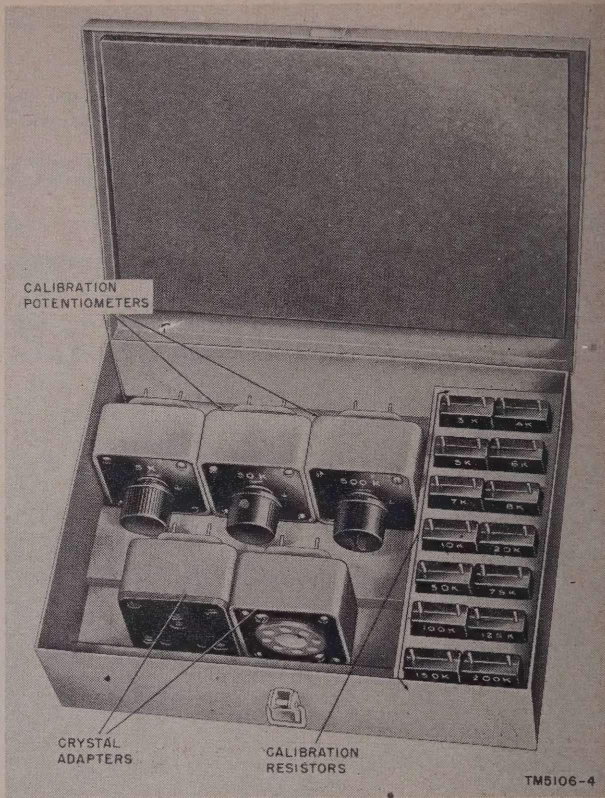


Figure 2. Accessory box.

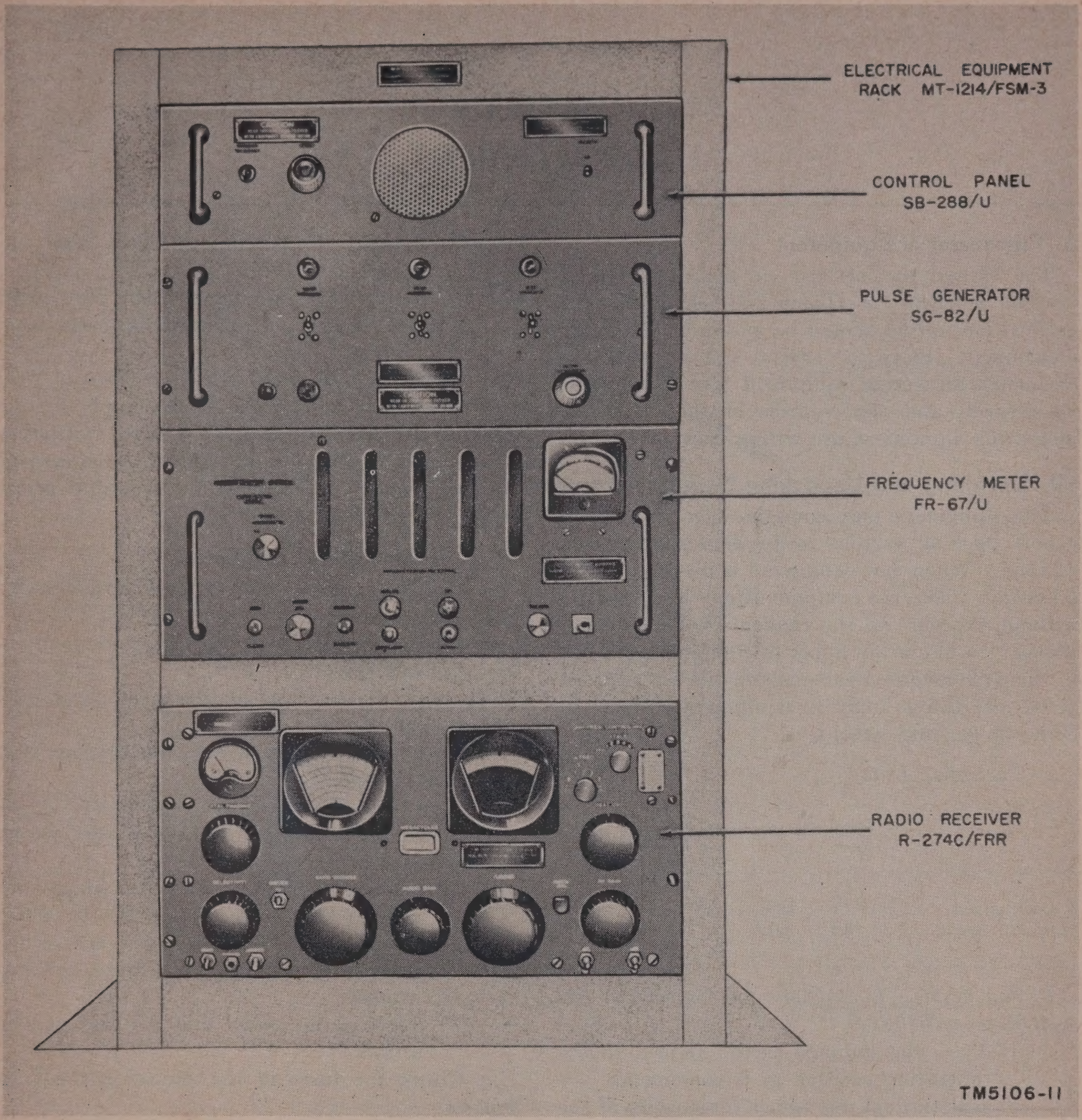


Figure 3. Frequency Measuring Group OA-484/FSM-3.

CHAPTER 2
INSTALLATION

9. Placement of Equipment

The crystal test set can be rack-mounted or used on a bench A 115- or 230-volt alternating current (ac) outlet should be within 6 feet of the instrument. Place the crystal test set near the frequency measuring equipment (par. 8) so that its controls and the controls of the frequency measuring equipment are within easy reach.

10. Uncrating and Unpacking New Equipment

The equipment may sometimes be shipped in export packing cartons or in domestic packing cartons. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements. The instructions given in *b* below apply to equipment shipped in export corrugated cartons and the instructions given in *c* below apply to equipment shipped in domestic packing cartons.

a. Packaging Data.

	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Unit weight (lb)
Export carton	17	25½	15½	3. 9	52
Domestic carton	14	22½	14	2. 6	47

b. Step-by-Step Instructions for Unpacking Export Shipments (fig. 4).

(1) Place the shipping carton as near to the operating position as is convenient.

(2) Cut through the upper three edges of the carton. The uncut edge will act as a hinge.

(3) Open the carton and remove the outer corrugated carton and the water-vapor-proof barrier around the carton.

(4) Cut the barrier as close to the seal as possible and carefully remove the barrier material.

(5) Open the carton as described in (2) above.

(6) Remove the inner corrugated carton and open the carton as described in (2) above.

(7) Remove the corrugated fillers from the carton.

(8) Remove the equipment from the carton and place it on the work bench or near its final location.

c. Unpacking Domestic Packing Carton. The instructions given in *b* above, also apply to unpacking domestic shipments. If heavy wrapping paper has been used around the corrugated carton, carefully remove it and follow the procedure given in *b*(5), (6), (7), and (8) above.

11. Checking New Equipment

a. Check the contents of the packing container with the packing slip.

b. Check to see that all the minor components are furnished (par. 6).

c. Check the contents of the spare parts containers (par. 7).

d. Check the contents of the accessory box (fig. 2 and pars. 4 and 5).

e. Inspect all items for damage (par. 2).

f. Check the tubes in the crystal test set as follows:

(1) Remove the nine screws that secure the cover to the chassis and remove the cover.

(2) Check to see that the tubes are secure in their sockets (fig. 9). Secure all the clamps.

(3) Replace the cover and the nine cover screws.

g. Check the fuses in the crystal test set as follows:

(1) Remove the fuse holder (fig. 5) and the fuse for examination. The fuse rating should be 2 amperes. Replace the fuse holder and the fuse.

(2) Remove the spare fuse holder and examine the SPARE fuse. The rating should be 2 amperes. Replace the fuse holder and the fuse.

Caution: Always use a 2-ampere fuse for replacement. The use of a fuse rated above this value may result in damage to the equipment.

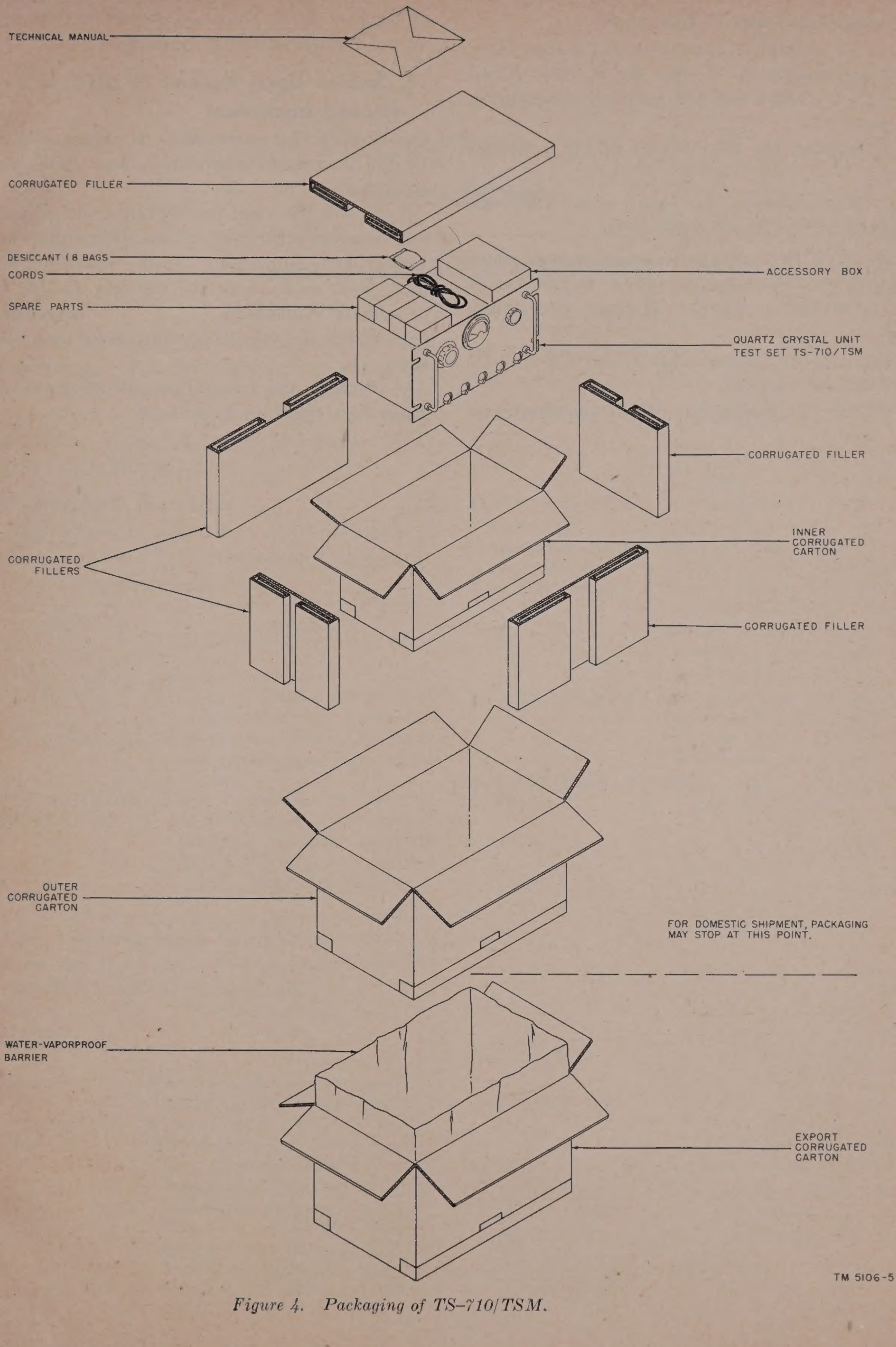


Figure 4. Packaging of TS–710/TSM.

12. Connections and Adjustments

Place the crystal test set close to the frequency measuring equipment so that the rf cable (Cord CG–433A/U) will reach the frequency measuring equipment.

a. Determine the line voltage of the ac power source.

Note. The ac power source must be either 115 or 230 volts, 50 to 1,000 cycles per second (cps).

b. Remove the voltage selector switch guard and move the switch handle (fig. 5) to the correct position (115V or 230V). Replace the switch guard.

c. Connect the power cable (Cord CX–112/U) to the ac power source.

d. Check the calibration of the ohmmeter on all ranges. Refer to paragraph 63 for instructions on the calibration of the ohmmeter.

13. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraphs 9 and 10 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications pertaining to the wiring of the equipment. If any changes in wiring have been made, note the changes on the wiring or schematic diagram.

c. Check the operating controls for ease of rotation.

d. Perform the installation and other procedures given in paragraphs 11 and 12.

CHAPTER 3
OPERATIONS

Section I. CONTROLS AND METER

14. General

Improper setting of the controls may damage the equipment. For this reason, it is important to know the function of the meter and of every control. This section explains their functions. The operation of the TS–710/TSM is explained in paragraphs 16 through 20.

15. Controls and Their Uses

a. The following chart lists the controls and receptacles on the rear of the crystal test set (fig. 5) and indicates their functions.

Control	Function
230V–115V voltage selector switch.	Permits connection of crystal test set to either a 115-volt or a 230-volt ac power source.
METER JACK	Permits connection of an external ammeter to the crystal test set.
OUTPUT coaxial connector receptacle.	Permits connection of a portion of the rf output of the oscillator (through rf cable assembly (Cord CG–433A/U)) to frequency measuring equipment.

b. The following chart lists the controls and meter on the front panel of the crystal test set (fig. 5) and indicates their functions:

Control	Function
Pilot lamp	When lighted, indicate power is being supplied to the equipment.
LOAD CAPACITY control.	Adjusts amount of load capacitance when test crystal is operated at antiresonance. Dial is calibrated in units from 0 to 100 and has a vernier drive and indicator. A calibration chart is provided with the equipment for converting capacitance in $\mu\mu f$ to LOAD CAPACITY dial indications.
A–R switch	Selects the type of operation of test crystal. In the A position, test crystal is operated at antiresonance. In the R position, test crystal is operated at series resonance.
OHMMETER socket.	Used to connect test resistor into ohmmeter circuit.
Actuator pin (ohmmeter switch).	Removes short across OHMMETER socket when depressed.
CRYSTAL socket	Used to connect test crystal into feedback path of the oscillator.
Meter	Indicates voltage across crystal or resistance of calibrating resistor in ohmmeter socket.
TUNING capacitor	Tunes oscillator to desired frequency in range indicated by position of FREQUENCY RANGE KILOCYCLES switch.
DRIVE VOLTAGE switch.	Selects amount of coarse drive voltage applied across test crystal. In 0.25, 2.5, and 25 positions, voltage is indicated on the 25-volt scale of meter. In 0.5 and 5.0 positions, voltage is indicated on the 5-volt scale of meter. In 1.0 and 10 positions, voltage is indicated on the 10-volt scale of meter. In all cases, maximum deflection of meter corresponds to associated DRIVE VOLTAGE switch setting.
GAIN control	Controls amount of fine drive voltage applied across test crystal.
SELECTOR switch	In OPERATE position, equipment is turned on and meter indicates volts. In Rx1, Rx10, and Rx100 positions, meter indicates ohms.
OHMMETER ZERO ADJUST.	Used to adjust meter needle to zero ohm position.
FREQUENCY RANGE KILOCYCLES switch.	Selects desired frequency range of oscillator.

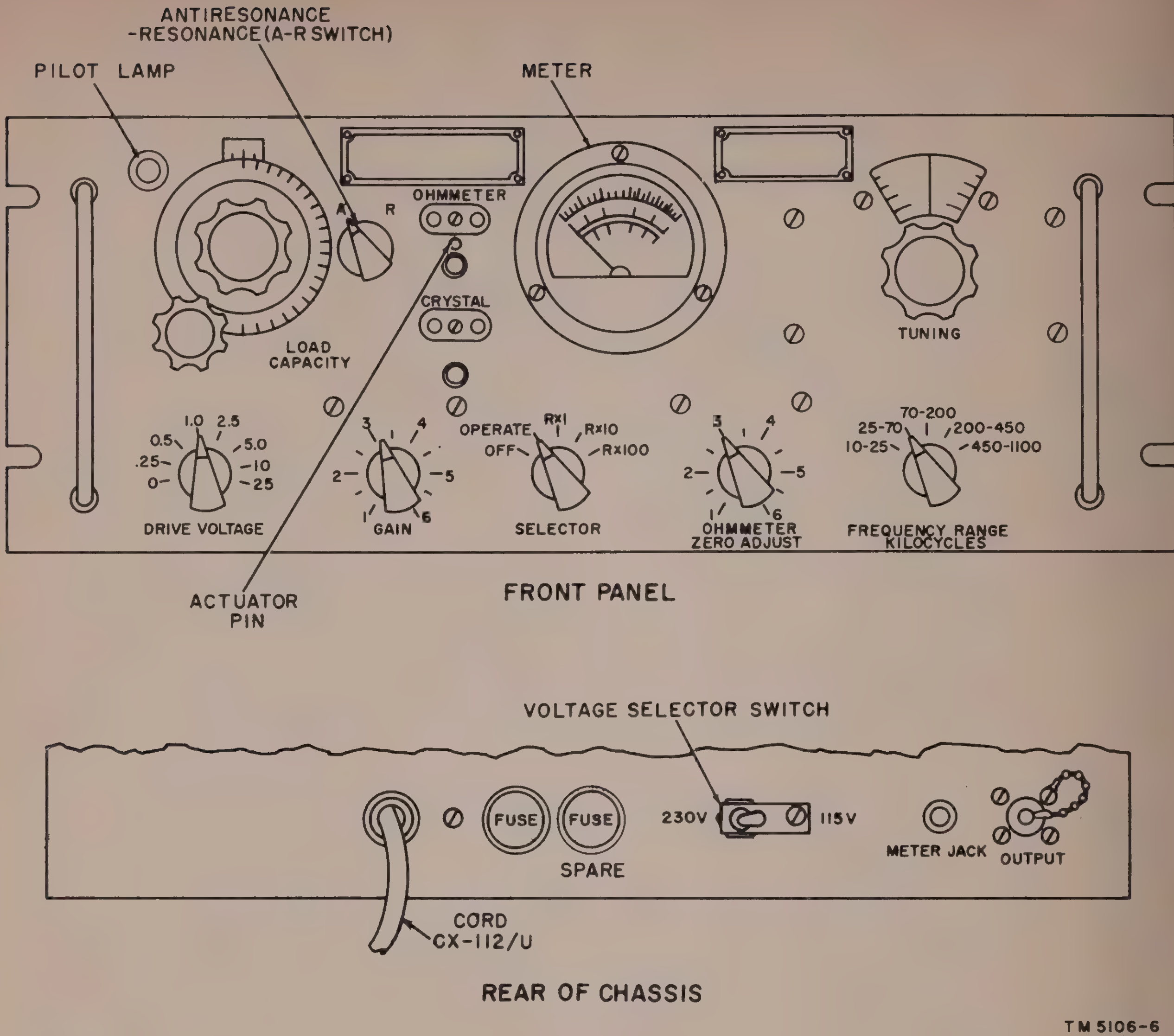


Figure 5. Crystal test set, controls and meter.

Section II. MEASURING FREQUENCY AND RESISTANCE OF CRYSTALS

Note. The procedures given in paragraphs 16 through 20 apply to the testing of individual crystals. Before making any crystal measurements, the operator must consult the applicable specification sheet. The description portion of the specification sheet states whether a crystal is operated at series-resonance or is operated into a load capacitance (antiresonant).

16. Starting Procedure

Perform the starting procedure given below before using the operating procedures described in paragraphs 17 through 25.

a. Preliminary.

(1) Insert the rf cable (Cord CG–433A/U) into OUTPUT jack J1 on the rear of the crystal test set (fig. 5).

(2) Set the front panel controls of the crystal test set as follows:

Control	Position
SELECTOR switch	OFF.
DRIVE VOLTAGE switch	Fully counterclockwise.
GAIN control	Fully counterclockwise.

b. Connections for Measurements of 100 Kc or Lower.

(1) Insert the rf cord, supplied with Frequency Meter FR–67/U, into the INPUT jack of the FR–67/U.

(2) Connect the bare end of the rf cord from the crystal test set to the bare end of the rf cord from the FR–67/U. Connect both the inner and the outer conductors of the coaxial cords.

c. Connections for Measurements Over 100 Kc.

(1) Insert Cord CG–433A/U into the UNKNOWN FREQUENCY jack of Control Panel SB–288/U, which is part of Frequency Measuring Group OA–484/FSM–3. Refer to the publication on Quartz Crystal Unit Test Set AN/FSM–3 for the method of connecting Frequency Measuring Group OA–484/FSM–3.

(2) Connect the bare end of the rf cord from the crystal test set to the bare end of the rf cord from the SB–288/U. Connect both the inner and outer conductors of the coaxial cords.

d. Starting.

(1) Refer to the publication on Quartz Crystal Unit Test Set AN/FSM–3 for instructions on setting the controls of the equipment in Frequency Measuring Group OA–484/FSM–3.

(2) Turn the SELECTOR switch of the crystal test set to the OPERATE position. The pilot lamp should light. Allow 15 minutes for the equipment to warm up.

17. Measurement of Series-Resonant Resistance and Frequency at Frequencies of 100 Kilocycles or Lower

Note. Crystals may start to oscillate slowly because of internal temperature cycling. Sufficient time should be allowed, after a crystal is inserted into the crystal test set, for the oscillation of the crystal to stabilize before measurements are taken. Otherwise the results obtained may be erratic.

a. Starting. Perform the starting operations described in paragraph 16*a*, *b*, and *d*.

b. Setting Drive Voltage.

(1) Turn the FREQUENCY RANGE KILOCYCLES switch (fig. 5) to the proper frequency range and adjust the TUNING control until the desired frequency (stamped on the case of the test crystal) is indicated on the scale.

(2) Turn the A–R switch to the R position.

(3) Insert the test crystal into the proper crystal adapter (if necessary) and insert this combination into the CRYSTAL socket.

(4) Turn the DRIVE VOLTAGE switch to the .25 position.

(5) Slowly advance the GAIN control while rotating the TUNING control back and forth through the frequency of the test crystal.

(*a*) If a meter indication is obtained, adjust the TUNING control for a maximum meter indication.

(*b*) If no meter indication is obtained with the GAIN control rotated to its full clockwise position, rotate the control counterclockwise and advance the DRIVE VOLTAGE switch to the next higher position.

(*c*) Repeat (5) above until a midscale meter indication is obtained.

Caution: Test crystals may start to oscillate very slowly and then build up quickly. Therefore, it is necessary to advance the GAIN control slowly during this procedure. Also at times, it is necessary to rotate the GAIN control counterclockwise (reducing the drive voltage) as soon as the crystal starts to oscillate, to prevent damaging the crystal unit.

(6) Adjust the SENSITIVITY control of Frequency Meter FR–67/U until the needle of the INPUT LEVEL meter lies in the green sector. This sets the input level for the correct operating value.

Note. This control may need readjustment throughout this test to keep the needle in the green sector of the meter.

(7) Note the frequency reading displayed on the FR–67/U. It should be approximately the frequency that is stamped on the case of the test crystal.

(8) Remove the test crystal from the CRYSTAL socket.

(9) Determine 70 percent of the maximum effective resistance of the test crystal (refer to the crystal specification sheet for the maximum effective resistance).

(10) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale (if possible) when measuring the resistance obtained in (9) above.

(11) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(12) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal (refer to crystal specification sheet).

(13) Adjust the calibration potentiometer to the value of resistance which is 70 percent of the maximum resistance of the test crystal ((9) above). Since most ohmmeters have a slight error in their readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed below.

(*a*) Insert a calibration resistor, whose value (*A* in (*b*) below) is *nearest* to 70 percent of the maximum resistance (*B* in (*b*) below), into the OHMMETER socket. Press the actuator pin below the OHMMETER socket to obtain a reading on the ohmmeter (*C* in (*b*) below).

(*b*) Insert the values (*A*, *B*, and *C*) obtained in (*a*) above into the formula given below. The computed result is the reading which must be indicated on the ohmmeter when the calibration potentiometer is inserted into the OHMMETER socket and adjusted.

$$\text{Meter reading for calibration potentiometer} = \frac{B \times C}{A}$$

Where:

A=actual value of calibration resistor

B=70% of maximum resistance specified for test crystals

C=meter reading

Example:

Actual value of calibration resistor	(A)=100,000 ohms
70% of maximum resistance specified for test crystals	(B)= 87,500 ohms
Meter reading for calibration resistor	(C)= 90,000 ohms

Meter reading for calibration potentiometer=

$$\frac{87{,}500 \times 90{,}000}{100{,}000} = 78{,}250 \text{ ohms}$$

(*c*) Remove the calibration resistor from the OHMMETER socket.

(*d*) Insert the calibration potentiometer into the OHMMETER socket and adjust it until the meter indicates the value of resistance obtained in (*b*) above.

(14) Remove the calibration potentiometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*

(15) Set the SELECTOR switch to the OPERATE position.

(16) Insert the calibration potentiometer into the CRYSTAL socket. *Be very careful not to disturb the setting of the potentiometer.*

(17) Determine the drive voltage to be applied to the test crystal. Since the power level, in the crystal specification, is usually given in milliwatts, it will be necessary to use the following formula.

$$E \text{ (volts)} = \sqrt{P \text{ (watts)} \times .7\, R \text{ (maximum effective resistance)}}.$$

Where:

E=drive voltage to be applied to test crystal.

P=level of drive given in crystal specification sheet.

R=maximum effective resistance of test crystal.

Example:

P=.1 milliwatt=.0001 watt

R=125,000 ohms

$E=\sqrt{.0001 \times 87{,}500}=\sqrt{8.75}=2.96$ volts

(18) Adjust the GAIN control until the meter indicates the value of drive voltage obtained in (17) above.

Note. It may be necessary to readjust the DRIVE VOLTAGE switch to the proper voltage range. Before adjusting the DRIVE VOLTAGE switch, turn the GAIN control fully counterclockwise.

(19) Adjust the TUNING control on the crystal test set until the frequency displayed on the FR–67/U is the same as was noted in (7) above ±0.1 percent.

Note. When the crystal test set is operated with the calibration potentiometer in the CRYSTAL socket, the frequency may not be constant.

(20) Readjust the GAIN control until the meter indicates the value of drive voltage obtained in (17) above.

Note. If this adjustment changes the frequency, a slight readjustment of the TUNING control may be necessary to again get a fre-

quency reading on the FR–67/U within ±0.1 percent of the frequency reading obtained in (7) above. Repeat these adjustments until both conditions given above are satisfactory.

(21) Remove the calibration potentiometer from the CRYSTAL socket.

Note. The settings of the DRIVE VOLTAGE switch and the GAIN control must not be disturbed throughout the remainder of this test.

c. Measuring Frequency and Resistance.

(1) Insert the test crystal into the CRYSTAL socket.

Note. If the meter goes off-scale, insert a 0- to 500-microampere meter into the METER JACK on the rear of the crystal test set and take all readings from it, instead of from the meter on the crystal test set.

(2) Note the frequency displayed on the FR–67/U. It should be the same (±0.1 percent) as was obtained in *b*(7) above. If it is not the same (±0.1 percent), it will be necessary to reset the drive voltage as described in *b* above.

(3) Note the reading on the meter.

(4) Remove the test crystal from the CRYSTAL socket.

(5) Insert the calibration potentiometer into the CRYSTAL socket.

(6) Adjust the potentiometer until the meter indicates the same value as was noted in (3) above.

(7) Adjust the TUNING control on the crystal test set until the frequency displayed on the FR–67/U is the same (±0.1 percent) as it was in *b*(7) above.

Note. If this adjustment changes the reading on the meter ((3) above), repeat (6) and (7) above until the meter indication is the same.

(8) Remove the calibration potentiometer from the CRYSTAL socket. Be very careful not to disturb the setting of the potentiometer.

(9) Insert the test crystal into the CRYSTAL socket.

(10) Note the reading on the meter. It should be the same as noted in (3) above.

Note. If the meter indication is different, repeat (4) through (10) above until the same meter indication is obtained for both the calibration potentiometer and the test crystal.

(11) Note the frequency displayed on the FR–67/U. *This is the actual frequency of the test crystal and should be within the tolerances given in the crystal specification sheet.*

(12) Remove the test crystal from the CRYSTAL socket.

(13) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale, if possible.

(14) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(15) Determine the resistance of the test crystal by measuring the resistance of the calibration potentiometer. Since most ohmmeters have a slight error in their readings, the final result must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed below.

(*a*) Insert the calibration potentiometer into the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.* The reading on the meter (*B* in (*e*) below) is the approximate resistance of the test crystal.

(*b*) Remove the calibration potentiometer from the OHMMETER socket.

(*c*) Insert a calibration resistor, whose value (*A* in (*e*) below) is *nearest* to the resistance obtained in (*a*) above, into the OHMMETER socket.

(*d*) Depress the actuator pin below the OHMMETER socket to obtain a reading on the meter (*C* in (*e*) below).

(*e*) Insert the values (*A*, *B*, and *C*) obtained in (*a*), (*c*), and (*d*) above into the formula given below to obtain a more accurate result for the resistance of the test crystal.

$$\text{Actual resistance} = \frac{A \times B}{C}$$

Where: A = actual value of calibration resistor.

B = meter reading for calibration potentiometer.

C = meter reading for calibration resistor.

Example:

Actual value of calibration resistor $(A)=100,000$

Meter reading for calibration potentiometer $(B)=110,000$

Meter reading for calibration resistor $(C)=90,000$

$$\text{Actual resistance}=\frac{100,000\times 110,000}{90,000}=122,222 \text{ ohms}$$

(*f*) Remove the calibration resistor from the OHMMETER socket.

(16) Turn off the equipment (par. 26).

18. Measurement of Series-Resonant Resistance and Frequency at Frequencies Above 100 Kilocycles

The procedures given below are similar to those used with crystals having a frequency of 100 kilocycles or less as described in paragraph 17. Since the frequencies are too high to be measured directly with the FR–67/U, it will be necessary to measure these frequencies using the equipment in Frequency Measuring Group OA–484/FSM–3 and Frequency Calibrator FR–70/U. Refer to the publication covering Quartz Crystal Unit Test Set AN/FSM–3 for instructions on the operation of this frequency measuring equipment.

Note. Crystals may start to oscillate slowly because of internal temperature cycling. Sufficient time should be allowed, after a crystal is inserted into the crystal test set, for the oscillation of the crystal to stabilize before measurements are taken, otherwise the results obtained may be erratic.

a. Starting. Perform the starting operations described in paragraph 16*a*, *c*, and *d*.

b. Setting Drive Voltage.

(1) Turn the FREQUENCY RANGE KILOCYCLES switch (fig. 5) to the proper frequency range and adjust the TUNING control until the desired frequency (stamped on the case of the test crystal) is indicated on the scale.

(2) Turn the A–R switch to the R position.

(3) Insert the test crystal into the proper crystal adapter (if necessary) and insert this combination into the CRYSTAL socket.

(4) Turn the DRIVE VOLTAGE switch to the 0.25 position.

(5) Slowly advance the GAIN control while rotating the TUNING control back and forth through the frequency of the test crystal.

(*a*) If a meter indication is obtained, adjust the TUNING control for a maximum meter indication.

(*b*) If no meter indication is obtained with the GAIN control rotated to its full clockwise position, rotate the control counterclockwise and advance the DRIVE VOLTAGE switch to the next higher position.

(*c*) Repeat (5) until a midscale meter indication is obtained.

Caution: Test crystals may start to oscillate very slowly and then build up quickly. Therefore, it is necessary to advance the GAIN control slowly during this procedure. Also, at times, it is necessary to rotate the GAIN control counterclockwise (reducing the drive voltage) as soon as the crystal starts to oscillate, to prevent damaging the crystal unit.

(6) Determine the harmonic that will be used to measure the frequency of the test crystal.

Note. Do not use a harmonic higher than the sixth.

(7) Rotate the TUNING control of Radio Receiver R–274C/FRR until a beat note is heard in the vicinity of the harmonic frequency ((6) above). Adjust the TUNING control until a zero beat is obtained.

(8) Remove the test crystal from the CRYSTAL socket.

(9) Determine 70 percent of the maximum effective resistance of the test crystal (refer to the crystal specification sheet for the maximum effective resistance).

(10) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale, (if possible) when measuring the resistance obtained in (9) above.

(11) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(12) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal (refer to the crystal specification sheet).

(13) Adjust the calibration potentiometer to the value of resistance which is 70 percent of the maximum resistance of the test crystal ((9) above). Since most ohmmeters have a slight error in their readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph 17*b*(13)(*a*) through (*d*).

(14) Remove the calibration potentiometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*

(15) Set the SELECTOR switch to the OPERATE position.

(16) Insert the calibration potentiometer into the CRYSTAL socket.

(17) Determine the drive voltage to be applied to the test crystal as described in paragraph 17*b*(17).

(18) Adjust the GAIN control until the meter indicates the value of drive voltage obtained in (17) above.

Note. It may be necessary to readjust the DRIVE VOLTAGE switch. Before adjusting the DRIVE VOLTAGE switch, turn the GAIN control fully counterclockwise.

(19) Adjust the TUNING control on the crystal test set until a zero beat is obtained.

Note. When the crystal test set is operated with the calibration potentiometer in the CRYSTAL socket, the frequency may not be constant.

(20) Readjust the GAIN control until the meter indicates the value of drive voltage obtained in (17) above.

Note. If this adjustment changes the frequency, a slight readjustment of the TUNING control may be necessary to again get a zero beat. Repeat these adjustments until a zero beat is obtained when the meter indicates the correct value of drive voltage.

(21) Remove the calibration potentiometer from the CRYSTAL socket.

Note. Do not disturb the settings of the DRIVE VOLTAGE switch and the GAIN control throughout the remainder of this test.

c. Measuring Frequency and Resistance.

(1) Insert the test crystal into the CRYSTAL socket.

Note. If the meter goes off-scale, insert a 0- to 500-microampere meters into the METER JACK on the rear of the crystal test set and take all readings from it, instead of from the meter on the crystal test set.

(2) Adjust the tuning control on Radio Receiver R–274C/FRR until a zero beat is obtained.

(3) Note the reading on the meter.

(4) Remove the test crystal from the CRYSTAL socket.

(5) Insert the calibration potentiometer into the CRYSTAL socket.

(6) Adjust the potentiometer until the meter indicates the same value as was noted in (3) above.

(7) Adjust the TUNING control on the crystal test set until a zero beat is obtained.

Note. If this adjustment changes the reading on the meter ((3) above) repeat (6) and (7) above until the meter indication is the same.

(8) Remove the calibration potentiometer the CRYSTAL socket. Be very careful not to disturb the setting of the potentiometer.

(9) Insert the test crystal into the CRYSTAL socket.

(10) Note the reading on the meter. It should be the same as that noted in (3) above.

Note. If the meter indication is different, repeat (4) through (10) above until the same meter indication is obtained for both the calibration potentiometer and the test crystal.

(11) Measure the frequency of the test crystal using Frequency Measuring Group OA–484/FSM–3. *This is the actual frequency of the test crystal and should be within the tolerances specified in the crystal specification sheet.*

(12) Remove the test crystal from the CRYSTAL socket.

(13) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale, is possible.

(14) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohms.

(15) Determine the resistance of the test crystal by measuring the resistance of the calibration potentiometer. Since most ohmmeters have a slight error in their readings, the final result must reflect the ohmmeter error. To obtain

a more accurate result from the ohmmeter, proceed as instructed in paragraph 17c(15)(a) through (f).

(16) Turn off the equipment (par. 26).

19. Measurement of Antiresonant Resistance and Frequency at Frequencies of 100 Kilocycles or Lower

The procedures given below are similar to those described in paragraph 17. The only difference is settings of the A–R switch and the setting of the LOAD CAPACITY dial.

Note. Crystals may start to oscillate slowly because of internal temperature cycling. Sufficient time should be allowed, after a crystal is inserted into the crystal test set, for the oscillation of the crystal to stabilize before measurements are made. Otherwise the results obtained may be erratic.

a. Starting. Perform the starting operations described in paragraph 16a, b, and d.

b. Setting Drive Voltage.

Caution: Do not insert the test crystal into the CRYSTAL socket while the A–R switch is in the R position because this may damage the crystal.

(1) Turn the FREQUENCY RANGE KILOCYCLES switch (fig. 5) to the proper frequency range and adjust the TUNING control until the desired frequency (stamped on the case of the test crystal) is indicated on the scale.

(2) Turn the A–R switch to the A position.

(3) Adjust the LOAD CAPACITY dial to the proper setting for the capacitance of the crystal being tested. (Refer to the crystal specification sheet.) Instructions for using the calibration chart to convert the crystal capacitance into the LOAD CAPACITY dial indication are given in paragraph 27.

(4) Insert the test crystal into the proper crystal adapter (if necessary) and insert this combination into the CRYSTAL socket.

(5) Turn the DRIVE VOLTAGE switch to the .25 position.

(6) Slowly advance the GAIN control while rotating the TUNING control back and forth through the frequency of the test crystal.

(a) When a meter indication is obtained, adjust the TUNING control for a maximum meter indication.

(b) If no meter indication is obtained with the GAIN control rotated to its full clockwise position, rotate the control counterclockwise and advance the DRIVE VOLTAGE switch to the next higher position.

(c) Repeat (6) until a midscale meter indication is obtained.

Caution: Test crystals may start to oscillate very slowly and then build up quickly. Therefore, it is necessary to advance the GAIN control slowly during this procedure. Also, at times, it is necessary to rotate the GAIN control counterclockwise (reducing the drive voltage) as soon as the crystal starts to oscillate, to prevent damaging the crystal unit.

(7) Adjust the SENSITIVITY CONTROL of Frequency Meter FR–67/U until the needle of the INPUT LEVEL meter lies in the green sector. This sets the input level for the correct operating value.

Note. This control may need readjustment throughout this test to keep the needle in the green sector of the meter.

(8) Note the frequency reading displayed on the FR–67/U. It should be approximately the frequency that is stamped on the case of the test crystal.

(9) Remove the test crystal from the CRYSTAL socket.

(10) Determine 70 percent of the maximum effective resistance of the test crystal (refer to the crystal specification sheet for the maximum effective resistance).

(11) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale (if possible) when measuring the resistance obtained in (10) above.

(12) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(13) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal (refer to the crystal specification sheet).

(14) Adjust the calibration potentiometer to the value of resistance which is 70 percent

of the maximum resistance of the test crystal ((10) above). Since most ohmmeters have a slight error in their readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph 17*b*(13)(*a*) through (*d*).

(15) Remove the calibration potentiometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*

(16) Set the SELECTOR switch to the OPERATE position.

(17) Turn the A–R switch to the R position.

(18) Insert the calibration potentiometer into the CRYSTAL socket.

(19) Determine the drive voltage to be applied to the test crystal as described in paragraph 17*b*(17).

(20) Adjust the GAIN control until the meter indicates the value of drive voltage obtained in (19) above.

Note. It may be necessary to readjust the DRIVE VOLTAGE switch. Before readjusting the DRIVE VOLTAGE switch, turn the GAIN control fully counterclockwise.

(21) Adjust the TUNING control on the crystal test set until the frequency displayed on the FR–67/U is the same as was noted in (8) above ±0.1 percent.

Note. When the crystal test set is operated with the calibration potentiometer in the CRYSTAL socket, the frequency may not be constant.

(22) Readjust the GAIN control until the meter indicates the value of drive voltage obtained in (19) above.

Note. If this adjustment changes the frequency, a slight readjustment of the TUNING control may be necessary to again get a frequency reading on the FR–67/U within ±0.1 percent of the frequency reading obtained in (8) above.

(23) Remove the calibration potentiometer from the CRYSTAL socket.

Note. The settings of the DRIVE VOLTAGE switch and the GAIN control must not be disturbed throughout the remainder of this test.

c. Measuring Frequency and Resistance.

(1) Turn the A–R switch to the A position.

(2) Insert the test crystal into the CRYSTAL socket.

Note. If the meter goes off-scale, insert a 0- to 500-microampere meter into the METER JACK on the rear of the crystal test set and take all readings from it, instead of from the meter on the crystal test set.

(3) Note the frequency displayed on the FR–67/U. It should be the same ±0.1 percent) as was obtained in *b*(8) above. If it is not the same (±0.1 percent) it will be necessary to reset the drive voltage as described in *b* above.

(4) Note the reading on the meter.

(5) Remove the test crystal from the CRYSTAL socket.

(6) Turn the A–R switch to the R position.

(7) Insert the calibration potentiometer into the CRYSTAL socket.

(8) Adjust the potentiometer until the meter indicates the same value as was noted in (4) above.

(9) Adjust the TUNING control on the crystal test set until the frequency displayed on the FR–67/U is the same (±0.1 percent) as that given in *b*(8) above.

Note. If this adjustment changes the reading on the meter ((4) above), repeat (8) and (9) above until the meter indication is the same.

(10) Remove the calibration potentiometer from the CRYSTAL socket. Be very careful not to disturb the setting of the potentiometer.

(11) Turn the A–R switch to the A position.

(12) Insert the test crystal into the CRYSTAL socket.

(13) Note the reading on the meter. It should be the same as was in (4) above.

Note. If the meter indication is different, repeat (5) through (13) above until the same meter indication is obtained for both the calibration potentiometer and the test crystal.

(14) Note the frequency displayed on the FR–67/U. *This is the actual frequency of the test crystal and should be within the tolerances given in the crystal specification sheet.*

(15) Remove the test crystal from the CRYSTAL socket.

(16) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch

that will give an ohmmeter reading between 0 ohm and midscale, if possible.

(17) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(18) Determine the resistance of the test crystal by measuring the resistance of the calibration potentiometer. Since most ohmmeters have a slight error in their readings, the final result must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter proceed as instructed in paragraph 17*c* (15)(*a*) through (*f*).

(19) Turn off the equipment (par. 26).

20. Measurement of Antiresonant Resistance and Frequency Above 100 Kilocycles

Note. Crystals may start to oscillate slowly because of internal temperature cycling. Sufficient time should be allowed, after a crystal is inserted into the crystal test set, for the oscillation of the crystal to stabilize before measurements are taken. Otherwise the results obtained may be erratic.

a. Starting. Perform the starting operations described in paragraph 16*a*, *c*, and *d*.

b. Setting Drive Voltage.

Caution: Do not insert the test crystal into the CRYSTAL socket while the A–R switch is in the R position because this may damage the crystal.

(1) Turn the FREQUENCY RANGE KILOCYCLES switch (fig. 5) to the proper frequency range and adjust the TUNING control until the desired frequency (stamped on the case of the test crystal) is indicated on the scale.

(2) Turn the A–R switch to the A position.

(3) Adjust the LOAD CAPACITY dial to the proper setting for the capacitance of the crystal being tested. (Refer to the crystal specification sheet.) Instructions for using the calibration chart to convert the crystal capacitance into the LOAD CAPACITY dial indication are given in paragraph 27.

(4) Insert the test crystal into the proper crystal adapter (if necessary) and insert this combination into the CRYSTAL socket.

(5) Turn the DRIVE VOLTAGE switch to the .25 position.

(6) Slowly advance the GAIN control while rotating the TUNING control back and forth through the frequency of the test crystal.

(*a*) When a meter indication is obtained with the GAIN control rotated on its full clockwise position, rotate the control counterclockwise and advance the DRIVE VOLTAGE switch to the next higher position.

(*b*) If no meter indication is obtained with the GAIN control rotated to its full clockwise position, rotate the control counterclockwise and advance the DRIVE VOLTAGE switch to the next higher position.

(*c*) Repeat (6) above until a midscale meter indication is obtained.

Caution: Test crystals may start to oscillate very slowly and then build up quickly. Therefore, it is necessary to advance the GAIN control slowly during this procedure. Also, at times, it is necessary to rotate the GAIN control counterclockwise (reducing the drive voltage) as soon as the crystal starts to oscillate, to prevent damaging the crystal unit.

(7) Determine the harmonic that will be used to measure the frequency of the test crystal.

Note. Do not use a harmonic higher than the sixth.

(8) Rotate the TUNING control of Radio Receiver R–274C/FRR until a beat note is heard in the vicinity of the harmonic frequency ((7) above). Adjust the TUNING control until a zero beat is obtained.

(9) Remove the test crystal from the CRYSTAL socket.

(10) Determine 70 percent of the maximum effective resistance of the test crystal (refer to the crystal specification sheet for the maximum effective resistance).

(11) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale (if possible) when measuring the resistance obtained in (10) above.

(12) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(13) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal (refer to the crystal specification sheet).

(14) Adjust the calibration potentiometer to the value of resistance which is 70 percent of the maximum resistance of the test crystal ((10) above). Since most ohmmeters have a slight error in thir readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph 17*b*(13)(*a*) through (*d*).

(15) Remove the calibration potentiometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*

(16) Set the SELECTOR switch to the OPERATE position.

(17) Turn the A–R switch to the R position.

(18) Insert the calibration potentiometer into the CRYSTAL socket.

(19) Determine the drive voltage to be applied to the test crystal, as described in paragraph 17*b*(17).

(20) Adjust the GAIN control until the meter indicates the value of drive voltage obtained in (19) above.

Note. It may be necessary to readjust the DRIVE VOLTAGE switch. Before adjusting the DRIVE VOLTAGE switch, turn the GAIN control fully counterclockwise.

(21) Adjust the TUNING control on the crystal test set until a zero beat is obtained.

Note. When the crystal test set is operated with the calibration potentiometer in the CRYSTAL socket, the frequency may not be constant.

(22) Readjust the GAIN control until the meter indicates the value of drive voltage obtained in (19) above.

Note. If this adjustment changes the frequency, a slight readjustment of the TUNING control may be necessary to again get a zero beat. Repeat these adjustments until a zero beat is obtained when the meter indicates the correct value of drive voltage.

(23) Remove the calibration potentiometer from the CRYSTAL socket.

Note. Do not disturb the settings of the DRIVE VOLTAGE switch and the GAIN control throughout the remainder of this test.

c. Measuring Frequency and Resistance.

(1) Turn the A–R switch to the A position.

(2) Insert the test crystal into the CRYSTAL socket.

Note. If the meter goes off-scale, insert a 0- to 500-microampere meter into the METER JACK on the rear of the crystal test set and take all readings from it, instead of from the meter on the crystal test set.

(3) Adjust the TUNING control of Radio Receiver R–274C/FRR until a zero beat is obtained.

(4) Note the reading on the meter.

(5) Remove the test crystal from the CRYSTAL socket.

(6) Turn the A–R switch to the R position.

(7) Insert the calibration potentiometer into the CRYSTAL socket.

(8) Adjust the potentiometer until the meter indicates the same value as was noted in (4) above.

(9) Adjust the TUNING control on the crystal test set until a zero beat is obtained.

Note. If this adjustment changes the reading on the meter ((4) above), repeat (8) and (9) above until the meter indication is the same.

(10) Remove the calibration potentiometer from the CRYSTAL socket. *Be very careful not to disturb the setting of the potentiometer.*

(11) Turn the A–R switch to the A position.

(12) Insert the test crystal into the CRYSTAL socket.

(13) Note the reading on the meter. It should be the same as that noted in (4) above.

Note. If the meter indication is different, repeat (5) through (13) above until the same meter indication is obtained for both the calibration potentiometer and the test crystal.

(14) Measure the frequency of the test crystal using Frequency Measuring Group OA–484/FSM–3. *This is the actual frequency of the test crystal and should be within the tolerances specified in the crystal specification sheet.*

(15) Remove the test crystal from the CRYSTAL socket.
(16) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale, if possible.
(17) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.
(18) Determine the resistance of the test crystal by measuring the resistance of the calibration potentiometer. Since most ohmmeters have a slight error in their readings, the final result must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph 17*c*-(15)(*a*) through (*f*).
(19) Turn off the equipment (par. 26).

Section III. USING CRYSTAL TEST SET AS GO NO-GO GAGE

21. General

The go no-go method of checking crystals is to be used only as a rapid method of checking a quantity of crystals. This method has inherent inaccuracies; therefore, the results obtained from using this method should be checked against accurate measurements made by following the procedures described in paragraphs 17 through 20 to determine if the accuracy of the go no-go method is sufficient for the intended use. When using this method, the crystals must be checked in groups. All crystals within a group must be of the same type and nominal frequency; the only variations being in the values of their effective resistance and actual frequency.

22. Antiresonant Operation at Frequencies of 100 Kilocycles or Lower.

a. Starting. Perform the starting operations described in paragraph 16*a*, *b*, and *d*.

b. Setting Drive Voltage. Perform the operations described in paragraph 19*b* for setting the drive voltage of an antiresonant crystal.

c. Setting Passing Activity Point.

(1) Determine the maximum effective resistance of the test crystal (refer to the crystal specification sheet).
(2) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale (if possible), when measuring the maximum effective resistance.
(3) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.
(4) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal ((1) above).
(5) Adjust the calibration potentiometer to the maximum resistance of the test crystal ((1) above). Since most ohmmeters have a slight error in their readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph 17*b*(13)(*a*) through (*d*).
(6) Remove the calibration potentiometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*
(7) Set the SELECTOR switch to the OPERATE position.
(8) Insert the calibration potentiometer into the CRYSTAL socket.
(9) Adjust the TUNING control on the crystal test set until the frequency displayed on the FR–67/U is the same as was noted in *b* above.
(10) Note the reading on the meter. *This is the passing activity point.*
(11) Remove the calibration potentiometer from the CRYSTAL socket.
(12) Turn the A–R switch to the A position.
(13) Insert the crystals that are being tested into the CRYSTAL socket. Crystals that cause a higher reading on the meter than that obtained in (10) above pass the resistance requirements; those showing less, fail.
(14) Note the frequency displayed on the FR–67/U. It should be within the toler-

ance specified in the crystal specification sheet.

(15) Repeat (13) and (14) above for each crystal of the group being tested.

Note. Each time the test crystal frequency is changed, repeat the procedure given in *a*, *b*, and *c* above.

23. Antiresonant Operation at Frequencies Above 100 Kilocycles

a. Starting. Perform the starting operations described in paragraph 16*a*, *c*, and *d*.

b. Setting Drive Voltage. Perform the operations described in paragraph 20*b* for setting the drive voltage of an antiresonant crystal.

c. Setting Passing Activity Point.

(1) Determine the maximum effective resistance of the test crystal (refer to the crystal specification sheet).

(2) Set the SELECTOR switch in either the Rx1, the Rx10, or the Rx100 position. Use the position of the SELECTOR switch that will give an ohmmeter reading between 0 ohm and midscale (if possible) when measuring the maximum effective resistance.

(3) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(4) Select the calibration potentiometer that has the lowest value of resistance which is higher than the maximum resistance of the test crystal ((1) above).

(5) Adjust the calibration potentiometer to the maximum resistance of the test crystal ((1) above). Since most ohmmeters have a slight error in their readings, this adjustment must reflect the ohmmeter error. To obtain a more accurate result from the ohmmeter, proceed as instructed in paragraph17*b*(13)(*a*) through (*d*).

(6) Remove the calibration potenitometer from the OHMMETER socket. *Be very careful not to disturb the setting of the potentiometer.*

(7) Set the SELECTOR switch to the OPERATE position.

(8) Insert the calibration potentiometer into the CRYSTAL socket.

(9) Adjust the TUNING control of the crystal test set until a zero beat is obtained.

(10) Note the reading on the meter. *This is the passing activity point.*

(11) Remove the calibration potentiometer from the CRYSTAL socket.

(12) Turn the A–R switch to the A position.

(13) Insert the crystals that are being tested into the CRYSTAL socket. Crystals that cause a higher reading on the meter than that obtained in (10) above pass the resistance requirements; those showing less, fail.

(14) Measure the frequency of the crystal being tested; use Frequency Measuring Group OA–484/FSM–3. The frequency should be within the tolerance specified in the crystal specification sheet.

(15) Repeat (13) and (14) above for each crystal of the group being tested.

Note. Each time the test crystal frequency is changed, repeat the procedure given in *a*, *b*, and *c* above.

24. Series-Resonant Operation at Frequencies of 100 Kilocycles or Lower

a. Starting. Perform the starting operations described in paragraph 16*a*, *b*, and *d*.

b. Setting Drive Voltage. Perform the operations described in paragraph 17*b* for setting the drive voltage of a series-resonant crystal.

c. Setting Passing Activity Point. Perform the operations described in paragraph 22*c* for setting the passing activity point with one exception; omit step (12).

25. Series-Resonant Operation at Frequencies Above 100 Kilocycles

a. Starting. Perform the starting operations described in paragraph 16*a*, *c*, and *d*.

b. Setting Drive Voltage. Perform the starting operations described in paragraph 18*b* for setting the drive voltage of a series-resonant crystal.

c. Setting Passing Activity Point. Perform the operations described in paragraph 23*c* for setting the passing activity point with one exception; omit step (12).

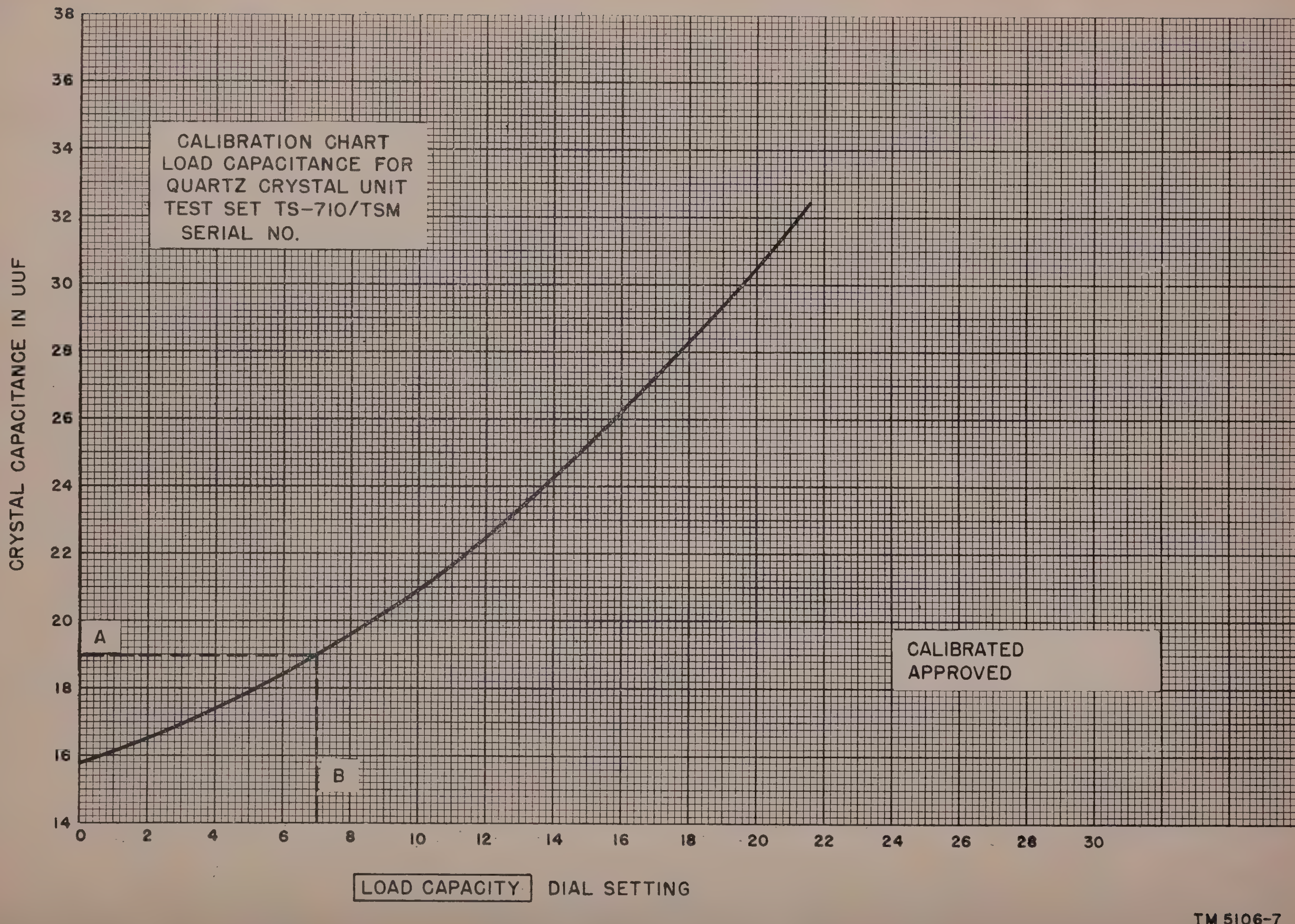


Figure 6. Typical calibration chart.

Section IV. FINAL OPERATING PROCEDURES

26. Stopping Procedure

a. Turn the SELECTOR switch to the OFF position.

b. Turn the DRIVE VOLTAGE switch to the 0 position.

c. Turn the GAIN control to its full counterclockwise position.

d. Disconnect the line cord from the power outlet.

27. Use of Calibration Chart for LOAD CAPACITY Dial Indication

a. The LOAD CAPACITY dial is engraved with numbers from 0 to 100. Crystal specification capacitance in $\mu\mu f$ can be converted into dial numbers by using the calibration chart (fig. 6) supplied with each crystal test set. This chart is prepared especially for each crystal test set; *be sure that the serial number on the chart corresponds with the serial number on the crystal test set.* Figure 6 illustrates one side of a typical calibration chart.

b. To convert crystal capacitance in $\mu\mu f$ to a LOAD CAPACITY dial number, proceed as follows:

(1) Locate the capacitance value setting on the ordinate (A, fig. 6) of the chart.

(2) Trace this value to the curve.

(3) Find the equivalent abscissa value (B, fig. 6). This is the number on the LOAD CAPACITY dial.

Example:

Capacitance value from crystal specification sheet (A, fig. 6) = 19 $\mu\mu f$ LOAD CAPACITY dial setting (B, fig. 6) = 7

Section V. OPERATION UNDER UNUSUAL CONDITIONS

28. General

The operation of the Quartz Crystal Unit Test Set TS–710/TSM may be difficult in regions where extreme cold, heat, humidity and moisture, or sand conditions prevail. Although every precaution is taken in the design of the equipment to maintain its technical characteristics over a wide temperature and humidity range, adverse conditions may cause errors in measurements unless additional precautions are taken. Paragraphs 29 through 31 provide procedures that minimize the effects of these unusual climatic conditions.

29. Operation in Winter Climates

Subzero temperatures and climatic conditions associated with cold weather affect the operation of the TS–710/TSM.

a. Handle the TS–710/TSM carefully. Keep the equipment warm and dry.

b. If cold equipment is brought into a warm room, it will sweat until it reaches room temperature. When the equipment has reached room temperature, dry it thoroughly.

30. Operation in Tropical Climates

In tropical climates, the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than that of the surrounding air. To minimize this condition, keep the set turned on.

31. Operation in Desert Climates

a. The main problem that arises with equipment operation in desert areas is the large amount of wind-driven sand, dust, or dirt which enters moving parts. The ideal preventive precaution is to house the equipment in a dustproof shelter.

b. Keep the equipment as free from dust as possible. Make frequent preventive maintenance checks (pars. 34–37).

CHAPTER 4
ORGANIZATIONAL MAINTENANCE

Section I. TOOLS AND EQUIPMENT

32. General

The user of the TS–710/TSM performs all the necessary organizational maintenance on this equipment. The tools, materials, and test equipment required to perform this maintenance are listed in paragraph 33 and are authorized by appropriate publications.

33. Tools, Test Equipment, and Materials

Tools, test equipment, and materials used, but not supplied with the TS–710/TSM are listed below.

a. Tools and Test Equipment.

(1) Tool Equipment TE–41
(2) Knife TL–29
(3) Tube Puller TL–201
(4) Orange stick
(5) Multimeter TS–297/U
(6) Electron Tube Test Set TV–7/U

b. Materials.

(1) Cheesecloth, bleached, lint-free*
(2) Cleaning compound (Federal stock No. 7930–395–9542)
(3) Sandpaper No. 000*
(4) Friction tape

*Part of Tool Equipment TE–41

Section II. PREVENTIVE MAINTENANCE SERVICES

34. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order and to limit breakdowns and interruptions in service. Preventive maintenance differs from troubleshooting and repair in that its object is to prevent certain troubles from occurring.

35. General Preventive Maintenance Techniques

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning. Clean electrical contacts (only when necessary) with a cloth moistened with cleaning compound. When cleaning the parts, it may sometimes be necessary to moisten the cloth or brush with cleaning compound. After cleaning, wipe dry with a cloth.

Caution: Repeated contact of cleaning compound with the skin, or prolonged breathing of the fumes, is dangerous. Cleaning compound is flammable. Make sure that adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from difficult places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive-maintenance techniques, refer to TB SIG 178, Preventive Maintenance Guide for Radio Communication Equipment.

36. Use of Preventive Maintenance Forms (figs. 7 and 8)

a. DA Forms 11–238 and 11–239 are preventive maintenance checklists to be used by the operator as directed by his commander. Instructions for the use of each form appear on the reverse side of the form.

b. Some items in figures 7 and 8 are partially or totally applicable to the crystal test set. References in the item column are to paragraphs in text that contain additional maintenance information.

37. Performing Preventive Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Daily. The information given below applies both to DA Form 11–238 and DA Form 11–239. These items are performed daily when using DA

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.
QUARTZ CRYSTAL UNIT TEST SET TS-710/TSM	

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; X Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (~~receiver, transmitter, carrying cases,~~ *wire and cable,* ~~microphones,~~ *tubes, spare parts, technical manuals and accessories).* PAR. 37a (1)	✓	✓	✓	✓			
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 37a (2)	✓	✓	✓	✓			
3	~~CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.~~							
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS VIBRATORS, PLUG-IN COILS AND RESISTORS.~~							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, ~~WORN OR CHIPPED GEARS,~~ MISALIGNMENT, POSITIVE ACTION. PAR. 37a (3)	✓	X	✓	✓			
6	CHECK FOR NORMAL OPERATION. PAR. 37a (4)	✓	✓	✓	✓			

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	~~CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.~~		13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~	
8	INSPECT CASES, MOUNTINGS, ~~ANTENNAS, TOWERS,~~ AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 37b (1)	✓	14	CLEAN ~~AIR FILTERS, BRASS~~ NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 37b (4)	✓
9	INSPECT CORD, CABLE, WIRE, ~~AND SHOCK MOUNTS~~ FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 37b (2)	✓	15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 37b (5)	X
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.~~	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ~~ELECTRICAL~~ TRANSFORMERS, ~~POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS,~~ CAPACITORS, ~~GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. PAR. 37b (3)	✓	18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 5106-8

Figure 7. DA Form 11-238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.
QUARTZ CRYSTAL UNIT TEST SET TS-710/TSM	

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDI-TION	NO.	ITEM	CONDI-TION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (~~receiver, transmitter, carrying cases,~~ wire and cable, ~~microphones,~~ tubes, spare parts, technical manuals and accessories). PAR. 37 a (1)	✓	19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, ~~CAP CONNECTORS,~~ CRACKED SOCKETS: INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION ~~OF RECEIVER TYPE TUBES.~~ PAR. 37 c (1)	✓
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 37 a (2)	✓	20	~~INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.~~	
3	~~CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS.~~		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR. 37 c (2)	✓
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.~~		22	~~INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.~~	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, ~~WORN OR CHIPPED GEARS,~~ MISALIGNMENT, POSITIVE ACTION. PAR. 37 a (3)	✓	23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS. PAR. 37 c (3)	✓
6	CHECK FOR NORMAL OPERATION. PAR. 37 a (4)	✓	24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR. 37 c (4)	✓
7	~~CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.~~		25	~~INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.~~	
8	INSPECT ~~CASES, MOUNTINGS, ANTENNAS, TOWERS, AND~~ EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 37 b (1)	✓	26	CLEAN AND TIGHTEN SWITCHES, ~~TERMINAL BLOCKS, BLOWERS, RELAY CASES,~~ AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR. 37 c (5)	✓
9	INSPECT CORD, CABLE, WIRE, ~~AND SHOCK MOUNTS~~ FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 37 b (2)	✓	27	~~INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.~~	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		28	~~CHECK SETTINGS OF ADJUSTABLE RELAYS.~~	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		29	~~LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.~~	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ~~ELECTRICAL~~ TRANSFORMERS, ~~POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS,~~ CAPACITORS, ~~GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. PAR. 37 b (3)	✓	30	~~INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.~~	
13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR. 37 c (6)	✓
14	CLEAN ~~AIR FILTERS, BRASS~~ NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 37 b (4)	✓	32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING ~~AND OIL LEAKAGE.~~ PAR. 37 c (7)	✓
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 37 b (5)	✓	33	~~BEFORE SHIPPING OR STORING - REMOVE BATTERIES.~~	
16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.~~		34	~~INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.~~	
17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~		35	~~INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.~~	
18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~		36	~~INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.~~	
			37	MOISTURE AND FUNGIPROOF. PAR. 37 c (8)	✓
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA 1 MAY 51 FORM **11-239** REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. c8—16—64382-1

TM 5106-9

Figure 8. DA Form 11–239.

Form 11–238 and monthly when using DA Form 11–239.

(1) Check the equipment against the table of components (par. 5), the list of running spares (par. 7), and the list of additional equipment required (par. 8) to see that no components or parts are missing. Observe the general condition of the equipment.

(2) Check the suitability of the siting location and the installation (pars. 9 and 12) for normal operation. Make provisions, where necessary for operation under unusual conditions (pars. 29–31), such as in excessively dusty, damp, hot, or cold areas.

(3) Operate all front panel controls to check for binding, scraping, excessive looseness, and positive action. Rough action or binding indicates the need for cleaning or adjustment of the control.

(4) Check the set for normal operation (par. 17).

b. Weekly. The information given below applies both to DA Form 11–238 and DA Form 11–239. These items are performed weekly when using DA Form 11–238 and monthly when using DA Form 11–239.

(1) Remove dirt and moisture from the front panel, connectors, adapters, calibration resistors, and potentiometers. Inspect for corrosion and deterioration.

(2) Inspect the power cord and the rf cord for breaks, deterioration, and loose connectors.

(3) Inspect for looseness of accessible items, such as switches and knobs, LOAD CAPACITY dial, and locknuts on jacks and the pilot light assembly. Do not overtighten the screws.

Caution: Do not cause the load capacitor to shift position because the capacitor will have to be recalibrated.

(4) Clean the nameplates, windows of the meter, the tuning control, the LOAD CAPACITY dial and vernier, and the jewel pilot light assembly.

(5) Inspect the meter for damaged glass or case.

c. Monthly. The information given below applies to DA Form 11–239 and is performed monthly.

(1) Inspect the tubes (fig. 9) for loose envelopes. Inspect for insufficient spring tension on tube and capacitor clamps. Test the tubes (par. 42).

(2) Inspect fixed capacitors for discoloration or corrosion.

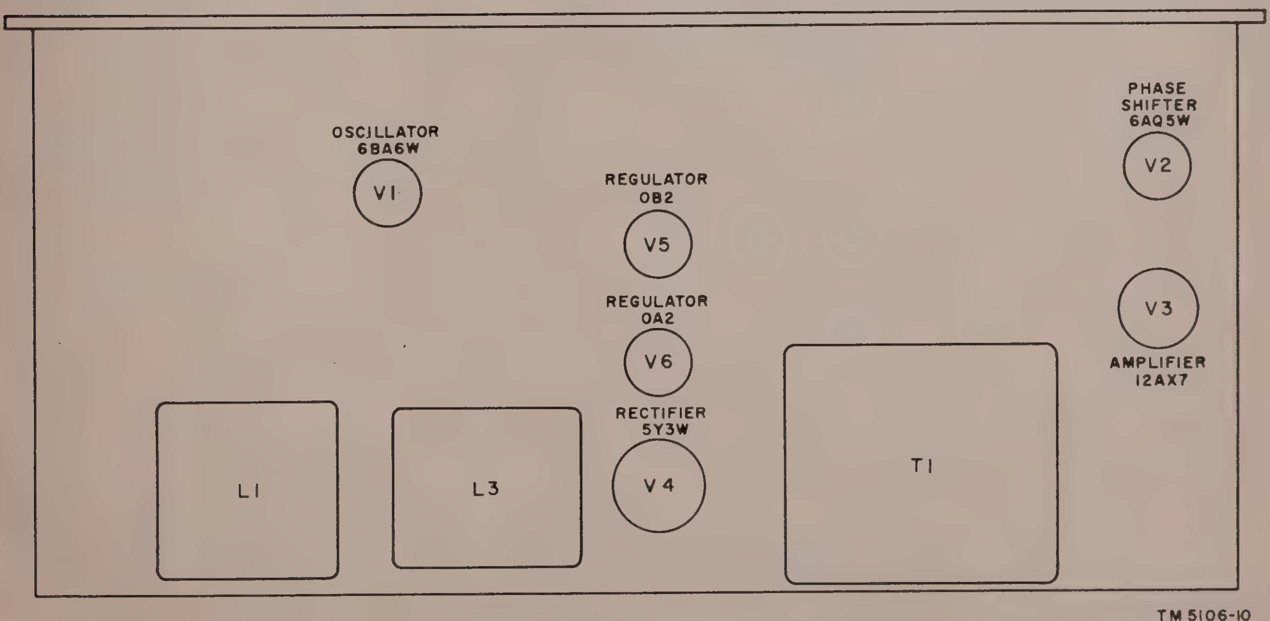


Figure 9. Tube location diagram.

(3) Inspect variable capacitors for dirt, moisture, misalinement of plates, and loose coupling. Do not bend the plates.

Caution: Do not cause the load capacitor to shift position because the capacitor will have to be recalibrated.

(4) Inspect the resistors, bushings, and insulators for cracks, chipping, blistering, and loose mountings.

(5) Clean and tighten switches and controls. Do not overtighten screws.

(6) Clean and tighten the connections and mountings of the transformer, coils, and potentiometers.

(7) Inspect the transformer and coils for overheating.

(8) Check moistureproof and fungiproof varnish for cracks and chipping.

Section III. LUBRICATION AND WEATHERPROOFING

38. Lubrication

No lubrication is required for the crystal test set. A lubricant is harmful because it will weaken the insulation and tend to collect dirt.

39. Weatherproofing

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical Maintenance of Ground Signal Equipment. The equipment is moistureproofed and fungiproofed. Further treatment is unnecessary except when treated parts are replaced or repaired.

c. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are given in TB SIG 66, Winter Maintenance of Signal Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

Section IV. TROUBLESHOOTING

40. General

a. Troubleshooting at organizational maintenance level (operator) is limited to the localizing of defective parts that are readily replaceable. The procedures outlined are designed to locate the fault. If the fault cannot be determined using the procedures given in paragraphs 41 through 43, the equipment must be turned in for repair.

b. Paragraphs 41 through 44 help in determining which of the circuits is at fault and in localizing the fault in the circuit to the defective stage or item, such as a tube or fuse.

Note. Preferred tube type 5Y3WGTA, developed as a direct replacement for tube type 5Y3WGT and used as rectifier V4, is interchangeable with this tube. The tube 5Y3WGT should be used until stocks are exhausted.

41. Visual Inspection

a. Inspection Items. Failure of this equipment to operate properly usually will be caused by one or more of the following faults:

(1) Defective tubes.

(2) Worn, broken, or disconnected cords or plugs.

(3) Burned-out fuses (par. 11*g*).

b. Inspection Procedure. When failure is encountered and the cause is not immediately apparent, check as many of the items given in *a* above as is practicable before starting a detailed examination. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred. Also, check the tubes (par. 42) if tube trouble is suspected.

42. Tube Checking Procedures

A high percentage of electron tubes are being discarded as faulty because of improper tube checking practices by maintenance personnel. Tubes discarded because the tube tester indicates their conditions as being slightly above the acceptability level may still have many hours of useful life. In many cases, such tubes may perform better in the crystal test set than new unproven replacements. Do not discard a tube until a tube tester check or replacement check indicates it to be at the end of its useful life. Use the following information as a guide in checking tubes with and without a tube tester.

a. Using Tube Tester. Remove and test one tube at a time. Always test the tube with the lowest filament voltage first and continue with tubes of progressively higher filament voltages. For example, if tube type 12AX7 were tested first and the tube tester filament voltage switch was left in the 12-volt position for tube type 5Y3WGT, the 5Y3WGT tube filament could be damaged. A low tube tester reading does not necessarily mean a poor tube. Check the tube tester settings against the tube test data supplied with the tube tester. Check a known good tube with the same panel settings and compare the readings.

b. Using Substitution Method. Replace the suspected tubes one at a time with new tubes. If the crystal test set becomes operative upon replacement of a tube, discard the last tube removed. The crystal test set meter may be used in a tube substitution procedure. If for example during testing of a crystal, the voltage reading on the crystal test set meter is lower than normal for a crystal known to be good, substitute one tube at a time and watch the crystal test set meter indicator for an increase in voltage. Discard the tube responsible for low meter indications. *Do not leave a new tube in a socket if the equipment operates satisfactorily with the original tube.*

43. Troubleshooting by Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 44) will help the operator to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the operator can take. *Follow the items in numerical sequence.*

b. Action or Condition. For some items, the information given in the action or condition column consists of various switch and control settings under which the item is to be checked. For other items, it represents an action that must be taken to check the normal indication given in the normal indications column.

c. Normal Indications. The normal indications listed include the visible and audible signs that the operator should notice when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those within the scope of the operator. If tube trouble is suspected, test the tubes (par. 42). If the set is completely inoperative or if the recommended corrective measures do not yield results, troubleshooting by a qualified repairman will be necessary.

44. Equipment Performance Checklist

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	SELECTOR switch	Set to OFF position.		
	2	115V–230V voltage selector switch.	Set to proper voltage shown beside cover plate.		
	3	DRIVE VOLTAGE switch	Set to 0 position.		
	4	GAIN control	Set to extreme counterclockwise position.		
START	5	SELECTOR switch	Turn to OPERATE position.	Pilot lamp lights	Check power cable for connection to proper source. Check fuse (par. 11*g*). Check lamp.
	6	CRYSTAL socket	Insert calibration resistor.		
	7	FREQUENCY RANGE KILOCYCLES switch.	Set to 10–25 position.		
EQUIPMENT PERFORMANCE	8	A–R switch	Turn to R position.		
	9	DRIVE VOLTAGE switch	Rotate switch in clockwise direction until meter indicates.	A position will be reached where meter indicates voltage across calibration resistor.	Check tubes (par. 42). Turn in equipment for adjustment or repair.
	10	GAIN control	Turn counterclockwise	Meter indicates more voltage across resistor.	Turn in equipment for adjustment or repair.
	11	FREQUENCY RANGE KILOCYCLES switch.	Switch to each range	Meter indicates voltage reading.	Turn in equipment for adjustment or repair.
	12	TUNING control	Rotate for each position of the FREQUENCY RANGE KILOCYCLES switch.	Meter indicates voltage reading.	Turn in equipment for adjustment or repair.
	13	A–R switch	Turn to A position.		
	14	CRYSTAL socket	Insert test crystal (antiresonant).	------------------------	Turn in equipment for adjustment or repair.
	15	DRIVE VOLTAGE switch	Rotate switch in clockwise direction until meter indicates.	Meter indicates voltage reading.	
	16	LOW CAPACITY control	Rotate counterclockwise	Meter indicates more voltage.	Turn in equipment for adjustment or repair.
	17	OHMMETER socket	Insert calibration resistor.		
	18	SELECTOR switch	Turn to Rx1 position.		
	19	OHMMETER ZERO ADJUST control.	Zero ohmmeter.		
	20	Actuator pin below the OHMMETER socket.	Press	Meter indicates value of calibration resistor directly in ohms.	Turn in equipment for adjustment.

44. Equipment Performance Checklist—Continued

	Item No.	Item	Action or condition	Normal indications	Corrective measures
EQUIPMENT PERFORMANCE	21	SELECTOR switch	Turn to Rx10 position.		
	22	OHMMETER ZERO ADJUST control.	Zero ohmmeter.		
	23	Actuator pin below OHMMETER socket.	Press	Meter indication multiplied by 10 is value of calibration resistor in ohms.	Turn in equipment for adjustment.
	24	SELECTOR switch	Turn to Rx100 position.		
	25	OHMMETER ZERO ADJUST control.	Zero ohmmeter.		
	26	Actuator pin below OHMMETER socket.	Press	Meter indication multiplied by 100 is value of calibration resistor in ohms.	Turn in equipment for adjustment.
STOP	27	GAIN control	Turn to extreme counterclockwise position.		
	28	DRIVE VOLTAGE switch	Turn to 0 position.		
	29	Calibration resistor	Remove and replace in accessory box.		
	30	SELECTOR switch	Turn to OFF position	Pilot light will go out.	

CHAPTER 5

THEORY

45. Crystal Theory, General

a. Piezoelectric Effect. When a voltage (electrical stress) is applied to a properly cut quartz crystal, a mechanical stress is produced in the crystal. Conversely, when a mechanical stress is applied to a properly cut crystal, a voltage will appear between the plates of the crystal. The polarity of the voltage and the direction of the corresponding mechanical stress are interrelated; a reversal in one causes a reversal in the other. This relationship between the electrical stress and mechanical stress is called the piezoelectric effect of a crystal.

b. Resonance. An alternating voltage applied to the plates of a quartz crystal causes the crystal to vibrate. If the frequency of the applied alternating voltage approximates a frequency of the mechanical resonance of a crystal, the amplitude of the vibrations will be greater. Crystals have several such mechanical resonant frequencies, depending on the crystal dimensions, the type of oscillation applied, and how the crystal is cut from the mother crystal.

c. Equivalent Electrical Circuit of a Crystal. The electrical circuit of a vibrating crystal is shown in figure 10. The capacity, C_o, represents the electrostatic capacity between the crystal plates when the crystal is in place but not vibrating. The series combination of L, C, and R represents the equivalent mass, compliance, and frictional loss of the vibrating crystal, respectively. Refer to TM 11–2540, Quartz Crystals Theory Fabrication and Performance Measurements, for a detailed explanation of the theory of an equivalent circuit of a crystal.

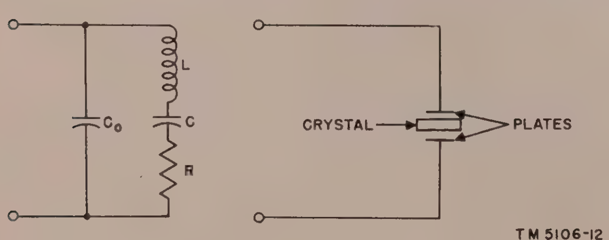


Figure 10. Equivalent electrical circuit of piezoelectric crystal.

46. Measurement of Crystal Parameters, General

a. Series Resonant and Antiresonant Resistances.

(1) The effective impedance of a test crystal is measured by application of the following principle of substitution:

(*a*) If an element of a system is removed and a substitute element is inserted in its place so that the original set of parameters (inductance, capacitance, and/or resistance values) is satisfied and no new ones are added, then the substitute element is operationally equivalent to the original element.

(*b*) If the parameters (amplitude and resonant crystal impedance) are measured in the circuit and an external resistor is substituted for the crystal in the same circuit without changing these parameters, then the external resistor represents the test crystal resistance or impedance.

(2) The test crystal may be operated at either a series-resonant frequency or at an antiresonant frequency.

(*a*) At *series* resonance, the equivalent electrical circuit of the crystal is purely *resistive*. At *antiresonance*, the equivalent electrical circuit of the crystal unit is *inductive*. Therefore, when the crystal test set is operated at an antiresonant frequency, and the correct value of load capacitor C3 is connected in series with the crystal, the combination of crystal and load capacitor C3 appears as pure resistance at the correct operating frequency.

(*b*) In either mode of operation, a resistor may be substituted for the crystal or for the combination of the crystal and load capacitor. This resistor can be adjusted to such a value that the am-

plitude of oscillations are the same as they were before the substitution was made. This value of resistance is, therefore, the effective series-resonant resistance or the effective antiresonant resistance.

b. Series-Resonant and Antiresonant Frequencies. Two methods have been described in paragraphs 17 through 20 for measuring the frequency of the crystals being tested.

(1) Frequencies of 100 kilocycles or lower are measured using Frequency Meter FR–67/U. The frequency displayed on the FR–67/U is the fundamental frequency being measured.

(2) Frequencies above 100 kilocycles are measured using Frequency Measuring Group OA–484/FSM–3. The range of the radio receiver in this equipment is from 540 kilocycles to 54 megacycles. Therefore, when a crystal frequency between 100 and 540 kilocycles is being measured, a harmonic of the fundamental frequency must be used to bring the fundamental frequency within the range of the radio receiver. The lowest harmonic is used to minimize interference from subharmonics.

47. Block Diagram analysis

The block diagram for the crystal test set is shown in figure 11. For more detailed information, refer to the schematic diagram (fig. 21).

a. Oscillator and Feedback Circuits. These circuits permit the resistance parameters of a test crystal to be measured. The tuned plate, untuned grid oscillator, may be varied in oscillation frequency from 10 to 1,100 kilocycles (kc) and consists of oscillator tube V1 and phase shifter tube V2. The test crystal or calibration resistor is inserted in the feedback path between these two tubes. An automatic gain control loop main-

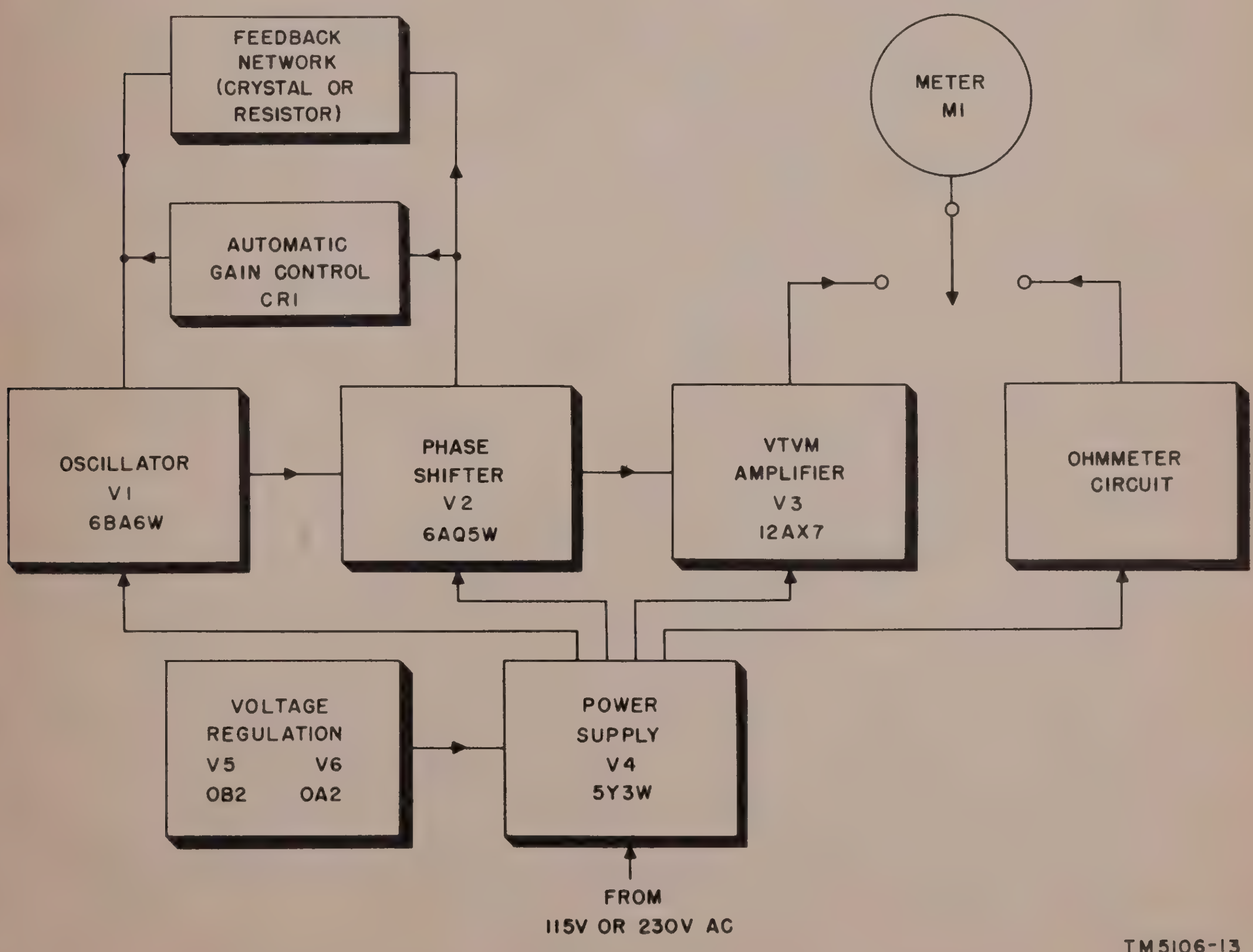


Figure 11. Quartz Crystal Unit Test Set TS–710/TSM, block diagram.

tains the voltage drop across the feedback loop at a constant potential.

b. Meter Circuits. The meter circuits provide a means for measuring voltage and resistance. Amplifier tube V3, when connected with meter M1, functions as a vacuum-tube voltmeter. The ohmmeter circuit, when connected with meter M1, functions as an ohmmeter.

c. Power Supply. The regulated power supply consists essentially of transformer T1, rectifier tube V4, and regulator tubes V6 and V5. The power supply provides 5.0 and 6.3 volts ac for the tube filaments, and 258 and 150 volts direct current (dc) for the plate supplies.

48. Oscillator and Feedback Circuit

The oscillator and feedback circuits (fig. 12), which provide a means for measuring the resistance parameters of a test crystal, consists essentially of oscillator tube V1 and phase shifter tube V2. The circuit functions as follows:

a. Oscillator Circuit.

(1) The frequency of oscillation of the circuit is determined by the selection of combinations of coils L1 and L2 and capacitors C6 and C10. This combination of capacitance and inductance is called a tank circuit. The tank circuit is selected, in five procedures, by FREQUENCY RANGE KILOCYCLES switch S3. The frequency of oscillation *within any band* is selected by TUNING capacitor C6.

(2) With SELECTOR switch S4 in the OPERATE position, plate voltage is applied to the tank circuit and the plate (pin 5) of tube V1, through dropping resistor R34. Capacitor C9A and resistor R34 form a decoupling network which prevents rf from reaching the B supply. Screen voltage is applied to the screen grid (pin 6) of tube V1 through dropping resistor R17. Capacitor C5 serves as an rf screen bypass. The cathode (pin 7) of tube V1 is biased by cathode bias resistor R16.

(3) The signal developed at the plate (pin 5) of tube V1 is applied through coupling capacitor C7 to the control grid (pins 1 and 7) of phase shifter tube V2.

b. Phase Shifter Circuit.

(1) Tube V2 shifts the phase of the output signal from tube V1 by 180° and feeds this signal back to tube V1.

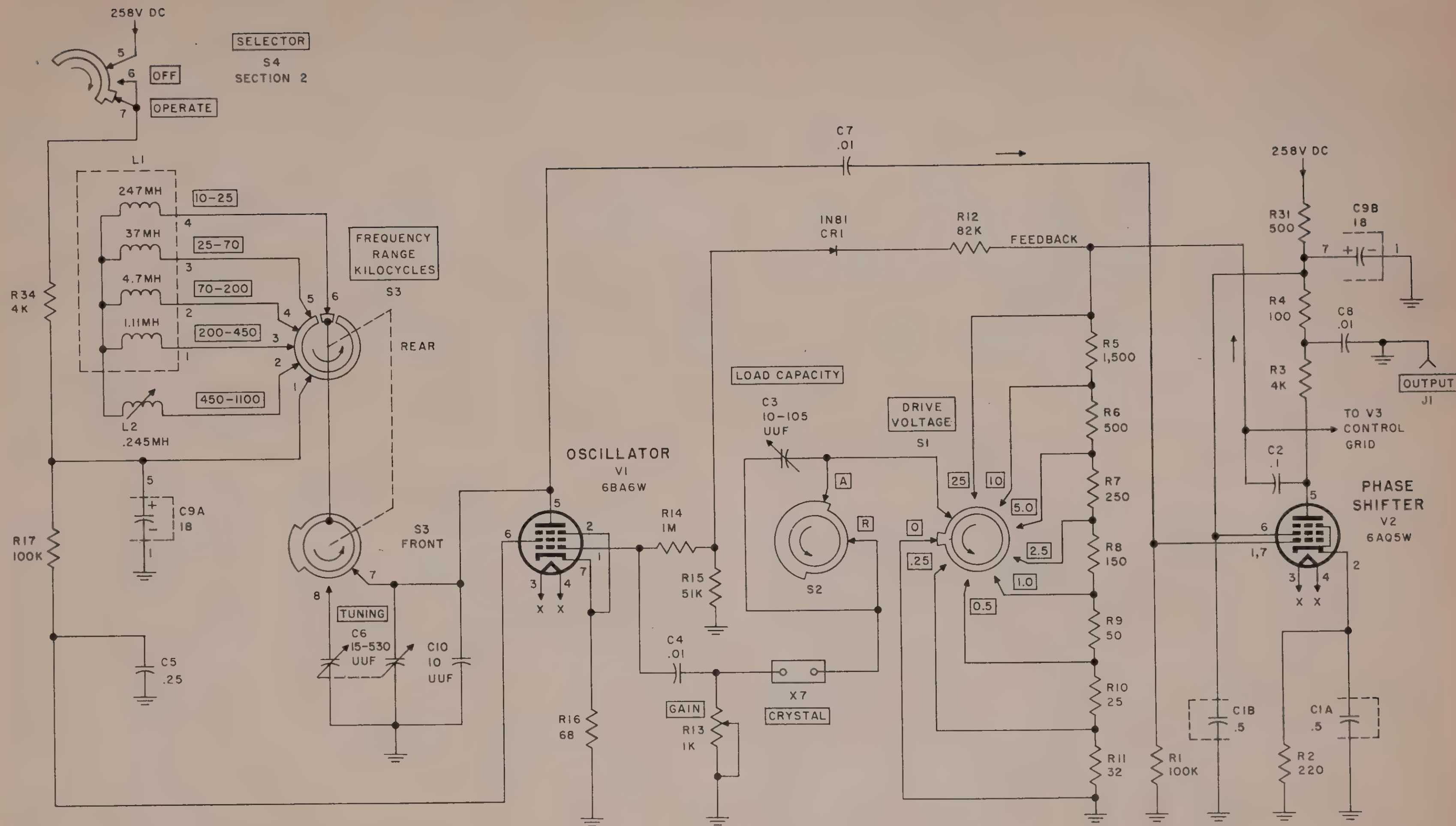
(2) The output from the plate (pin 5) of tube V1 is applied to the control grid (pins 1 and 7), of tube V2. The phase-shifted output from the plate (pin 5) of tube V2 is applied to the control grid (pin 1) of tube V1 to make tube V1 oscillate. Plate voltage is applied to the plate (pin 5) of tube V2 through resistors R31, R4, and R3. Resistor R31 is a plate and screen voltage-dropping resistor. Resistor R31 and capacitor C9B together, form a decoupling network. Voltage divider resistors R3 and R4 determine the rf output voltage which is applied through coupling capacitor C8 and made available at OUTPUT jack J1. Resistors R4 and R3 are also the tube V2 plate-loading resistors. Screen voltage is applied to the screen (pin 6), of tube V2 through voltage-dropping resistor R31.

(3) Capacitor C1B serves as an rf bypass. The cathode (pin 2) of tube V2 is biased by cathode bias resistor R2. Capacitor C1A provides the rf bypass path around resistor R2.

(4) Portions of the output signal developed at the plate (pin 5) of tube V2 are applied through coupling capacitor C2 to the vacuum-tube voltmeter, the automatic gain control, and the feedback circuits.

c. Automatic Gain Control and Feedback Loop. The feedback loop returns the phase-shifted signal from the plate (pin 5) of tube V2 to the control grid (pin 1) of tube V1. The automatic gain control loop maintains the voltage drop across the feedback circuit constant, to protect the test crystal inserted in the feedback loop.

(1) The automatic gain control loop consists of germanium rectifier CR1 (type IN81) and resistors R12, R14, and R15. Rectifier CR1 rectifies the feedback voltage through current limiting resistor R12 and resistor R15 and thereby develops a bias voltage across resistor R15. The grounded



NOTE:
SWITCHES ARE SHOWN IN THE FOLLOWING POSITIONS:
S1 [0], S2 [R], S3 [10-25], S4 [OPERATE].

TM5106-14

Figure 12. Oscillator and feedback circuits, simplified schematic diagram.

end of resistor R15 is positive with respect to the other end. Resistor R14 couples this voltage to the control grid (pin 1) of tube V1.

(2) In the feedback loop, the phase-shifted signal is fed through a selected portion of a voltage step attenuator consisting of resistors R5 through R11.

(3) DRIVE VOLTAGE switch S1 controls the amount of resistance and therefore the coarse adjustment of the drive voltage across the test crystal in CRYSTAL socket X7.

(4) The coarse drive voltage is applied across the test crystal through LOAD CAPACITY capacitor C3 or the capacitor jumper depending on the position of A–R switch S2. In the R (series resonance) position, switch S2 places a short across capacitor C3. In the A (antiresonance) position, switch S2 removes the short from across capacitor C3.

(5) GAIN resistor R13 is the fine drive voltage adjustment. Capacitor C4 prevents the dc in the automatic gain control loop from appearing across the test crystal.

49. Meter Circuit

In the meter circuit (fig. 13), meter M1 functions either as a vacuum-tube *voltmeter* or as an *ohmmeter*. With SELECTOR switch S4 in the OPERATE position, the meter indicates voltage. With SELECTOR switch S4 in the Rx1, Rx10, or Rx100 position, the meter indicates resistance.

a. Vacuum-Tube Voltmeter.

(1) A high-resistance vacuum-tube voltmeter is used (instead of an ordinary voltmeter) to prevent the meter circuit from loading down the oscillator circuit.

(2) The circuit functions as follows: A portion of the output from the plate (pin 5), of phase shifter tube V2 is coupled to the control grids (pins 2 and 7) of twin triode tube V3.

(3) Tube V3 is connected in parallel to provide double current-carrying capacity. The signal is amplified by tube V3 and applied to meter M1 via a voltage dividing network consisting of resistors R18 and R19 and closed circuit METER JACK J2.

(4) Capacitor C1C prevents the meter from being affected by the rf signals.

(5) Jack J2 provides a means for connecting an external meter to the circuit.

(6) The vacuum-tube voltmeter is zeroed by potentiometer R24.

(7) Potentiometer R22 across meter M1 permits full scale adjustment of the meter.

(8) Resistor R23, a voltage-dropping resistor, enables the meter to operate within proper range.

b. Ohmmeter.

(1) The ohmmeter measures the resistance of the calibration potentiometer and functions as follows (fig. 13): if one of the calibration potentiometers is inserted in OHMMETER socket X8, the actuator pin is pushed in and microswitch S5 is opened. This switch is normally closed to allow the ohmmeter to be zeroed.

(2) With SELECTOR switch S4 in the RX1 position, resistor R29 and potentiometer R30 provide a voltage across the series combination of the calibration potentiometer (which is assumed to be inserted in the OHMMETER socket), potentiometer R20, and meter M1. The meter then indicates the resistance of the calibration potentiometer directly in ohms.

(3) With SELECTOR switch S4 in the RX10 position, resistor R27 and potentiometer R28 provide a voltage across the series combination of the calibration potentiometer, potentiometer R20, and meter M1. The resistance value of the calibration potentiometer in ohms is the reading of meter M1 multiplied by 10.

(4) With SELECTOR switch S4 in the RX100 position, resistor R25 and potentiometer R26 provide a voltage across the series combination of the calibration potentiometer, potentiometer R20, and meter M1. The value of the calibration potentiometer in ohms is the reading of meter M1 multiplied by 100.

(5) OHMMETER ZERO ADJUST potentiometer R20 allows the ohmmeter to be zeroed.

(6) Resistor R21 is a shunt resistor across meter M1.

50. Power Supply

The B power supply (fig. 14) is a conventional type that converts either 115 or 230 volts, 50 to 1,000 cps ac to regulated dc necessary for the

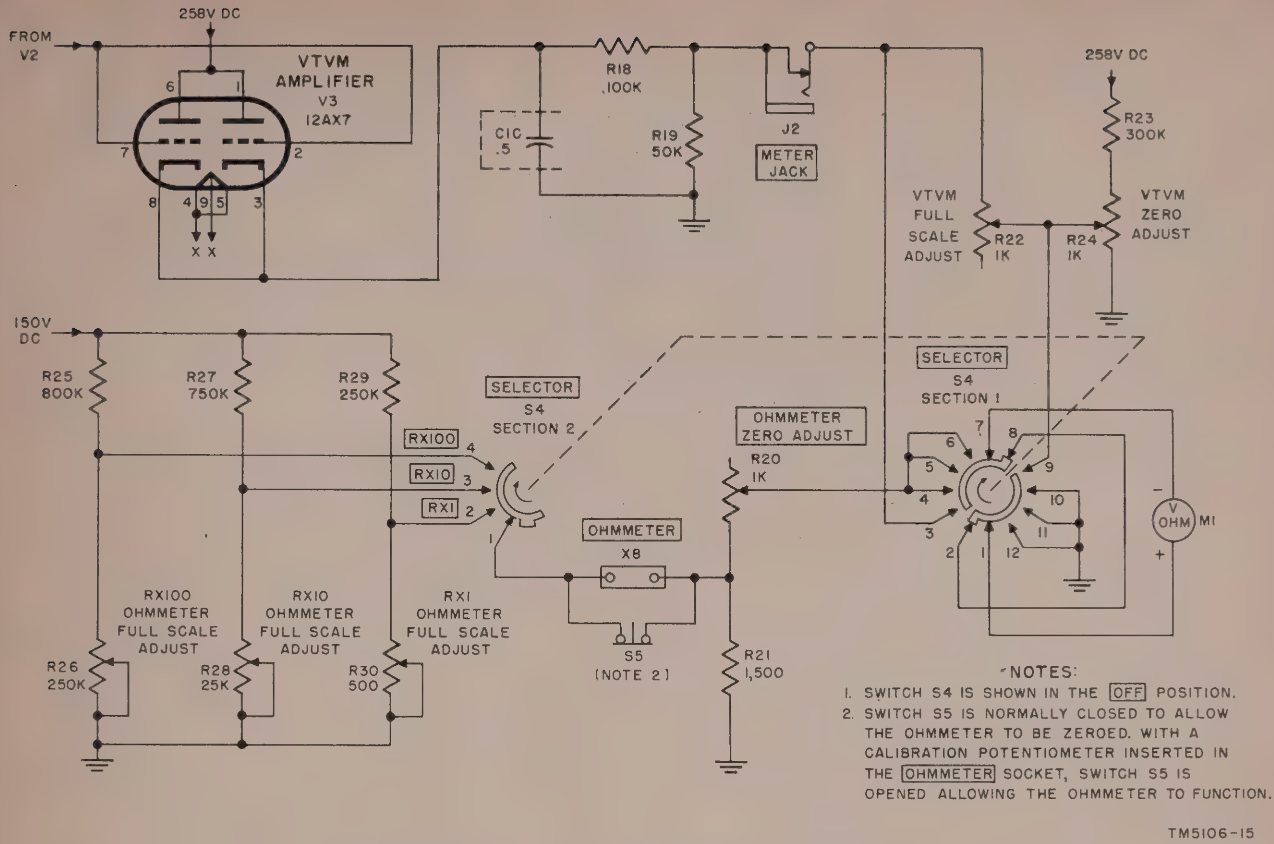


Figure 13. Meter circuit, simplified schematic diagram.

operation of the crystal test set. The power supply uses tube V4 as a full wave rectifier, tube V5 as one voltage regulator, and tube V6 as another voltage regulator. The circuit functions as follows:

a. With SELECTOR switch S4 in the OPERATE position, either 115 or 230 volts ac is applied to the primary of transformer T1 through the 2-ampere fuse F1.

(1) If 115 volts is supplied, with 230V–115V switch S6 in the 115V position, the two primary windings of transformer T1 are connected in parallel. The potential across each of the two primary windings of transformers T1 is 115 volts.

(2) If 230 volts is supplied, with 230V–115V switch S6 in the 230V position, the two primary windings of transformer T1 are connected in series and the potential across the combination is 230 volts. This, in effect, is a potential of 115 volts across each one of the primary windings.

b. Transformer T1 has secondary windings producing 1,080 volts at 100 milliamperes (ma); center-tapped for the plates of full wave rectifier tube V4; 5.0 volts at 2.0 amperes for the filament of tube V4, and 6.3 volts at 2.0 amperes center-tapped for all the other tube filaments and pilot lamp I 1. The 1,080 volts ac from the secondary of transformer T1 is applied to the plates (pins 4 and 6) of rectifier tube V4. The pulsating dc output of this tube appears between pin 2 and chassis.

c. The pulsating dc output is filtered by choke L3 and capacitor C9. Resistors R32 and R33 act as current limiting resistors for tubes V5 and V6. The filtered dc output is applied to the series combination of voltage regulators V5 and V6. The voltage regulators maintain the dc output voltages of the power supply constant. The dc output across both of these tubes is approximately 285 volts. The dc output from tube V6 and ground is 150 volts.

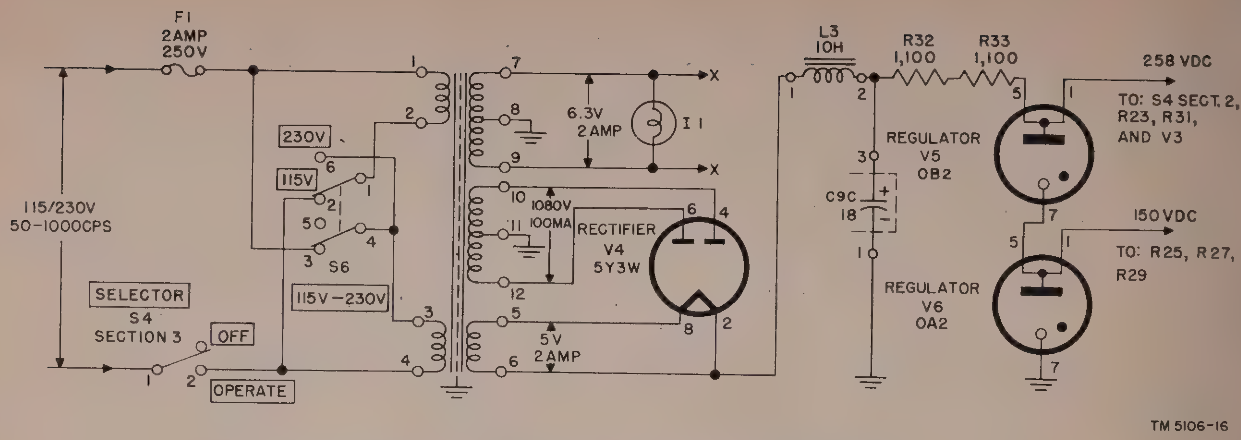


Figure 14. Power supply, simplified schematic diagram.

CHAPTER 6
FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairmen.

Section I. TROUBLESHOOTING

Warning: Certain points on the chassis of the crystal test set are 540 volts above ground. Do not touch these points while power is being applied. Be very careful when handling or testing any part of the crystal test set while it is connected to the power source.

51. Troubleshooting Procedures

a. General.

(1) The first procedure in servicing a defective crystal test set is to sectionalize the fault. Sectionalization means tracing the fault to the circuit responsible for the abnormal operation of the set.

(2) The second procedure is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition.

(3) Some faults, such as burned-out resistors, and shorted transformers, often can be located by sight, smell, and hearing. The majority of faults, however, are localized by checking tubes (par. 42), voltages, and resistances.

b. Sectionalization and Localization. Listed below is a group of tests arranged to aid in tracing trouble. Follow the procedure in the sequence given. A serviceman must be careful to cause no further damage to the set while it is being serviced. The service procedure is summarized as follows:

(1) *Visual inspection* (par. 41). Through visual inspection, the repairman frequently may discover the trouble and thus avoid possible damage to the crystal test set which might occur from complicated and improper servicing methods.

(2) *Operational test.* The operational test given by the equipment performance checklist (par. 44) is important because it may indicate the general location of trouble. In many instances, the information gained may indicate the exact nature of the fault. To utilize this information fully, all symptoms must be interpreted in relation to each other.

(3) *Troubleshooting chart.* The trouble symptoms listed in this chart (par. 55) will aid greatly in localizing the trouble.

(4) *Intermittents.* In all these tests, possibility of intermittent conditions should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the equipment or tubes (par. 56). Test wiring for loose connections with an insulated tool, such as an orange stick or pencil. This procedure may show where a faulty connection or part is located.

52. Troubleshooting Data

Caution: Always check the circuit label against the schematic diagram (fig. 21) for circuit changes made during equipment production. Consult the following troubleshooting data:

Fig.	Par.	Title
9		Tube location diagram.
15		Crystal test set, top rear view, location of parts.
16		Crystal test set, bottom view, location of parts.
17		Quartz Crystal Unit Test Set TS–710/TSM, voltage and resistance diagram.
19		MIL STD resistor color codes.
20		MIL STD capacitor color codes.
21		Quartz Crystal Unit Test Set TS–710/TSM, schematic diagram.
22		Quartz Crystal Unit Test Set TS–710/TSM, wiring diagram.
	56*d*	Dc resistances of transformers and coils.

53. Test Equipment Required for Troubleshooting

The items of test equipment required for troubleshooting the crystal test set are listed below. Technical manuals associated with each item are also listed.

Test equipment	Common name	Technical manual
Multimeter TS–352/U	Multimeter	TM 11–5527
Electron Tube Test Set TV–7/U.	Tube tester	TM 11–5083

54. General Precautions

Observe the following precautions very carefully when servicing the TS–710/TSM because careless replacement of parts often causes new faults.

a. Shut off power before removing the equipment from the dust cover.

b. If the crystal set has been operating for some time, use a cloth to remove the metal tube shields and a tube puller to remove the tubes, to prevent burning the fingers.

c. Do not overtighten screws when assembling mechanical parts.

d. When replacing a part that is held by screws, always replace the lockwashers.

e. Careless replacement of parts often makes new faults inevitable. Note the following points:

(1) Before a part is unsoldered, note the position of the leads. If the part, such as a transformer, has a number of connections tag each lead.

(2) Be careful not to damage other leads by pushing or pulling them out of the way.

(3) Do not use a large soldering iron when soldering small resistors or ceramic capacitors. Overheating of the small parts may alter the value of the part.

(4) Do not allow drops of solder to fall in the chassis; they may cause short circuits.

(5) A carelessly soldered connection may create new faults. It is very important to make well-soldered joints because a poorly soldered joint is one of the most difficult faults to find.

f. When servicing the rf oscillator assembly, note the following points:

(1) Do not attempt to service the rf and load capacity assemblies without proper equipment (par. 60).

(2) Do not disturb the placement of parts and be careful not to bend the tuning capacitor plates. This could cause a short circuit or a change of alinement.

(3) Replace parts in the oscillator circuit in their original positions. A part which has the same electrical value but a different physical size may cause trouble in the rf oscillator circuit.

(4) Lead positions are very critical in the oscillator circuit and must be replaced in the same position.

g. Be very careful to prevent burning out meter M1, it is very sensitive. The maximum permissible current is 1/10 milliampere. *Do not under any circumstances place an ohmmeter or more than 1/10 volt across meter M1.*

55. Troubleshooting Chart

The following chart is an aid in locating trouble in the crystal test set. It lists the symptoms which the repairman can observe and also indicates how to localize trouble quickly in the oscillator, meter, and power supply circuits. After the trouble has been localized to a circuit, a tube check and the voltage and resistance measurements of this circuit ordinarily should be sufficient to isolate the defective parts. Normal voltage and resistance readings are given in figure 17. Also refer to parts location diagrams (figs. 15 and 16) and to the complete schematic diagram (fig. 21). Figures referred to in the probable trouble column of the chart is the applicable partial schematic diagram. The figure referrred to in the correction column illustrates the element. Paragraphs referred to in the correction column contain information helpful in making repairs.

Item No.	Symptom	Probable trouble	Correction
1	Pilot lamp does not light with SELECTOR switch in the OPERATE position and 230V–115V switch in the correct position.	Cord not plugged into source or open.	Check at source and at unit (terminals 1 and 4 on T1).
		Blown fuse F1 (fig. 15)	Check and replace (see the Caution in par. 11*g*).
		Pilot light E1 burned out	Replace lamp.
		Defective SELECTOR switch S4	Check and replace.
		Defective 230V–115V switch S6	Check and replace.
		Transformer T1 open	Check and replace.
2	Voltage regulator tubes do not light	Defective tube V5 or V6	Replace tube (par. 42).
		Faulty rectifier tube V4 (fig. 15)	Replace tube.
		High voltage secondary of transformer T1 open (fig. 15).	Replace transformer T1.
		Choke coil L3 open	Replace coil.
3	No voltmeter or ohmmeter reading with controls set as required for normal operation and calibrator resistors or potentiometers in CRYSTAL and OHMMETER sockets. (A–R switch set to R).	Defective meter M1 (fig. 13)	Replace meter (pars. 62 and 63).
		Defective A–R switch	Replace A–R switch (par. 58).
4	No voltmeter reading with crystal in CRYSTAL socket and other controls set as required for normal operation.	Defective oscillator tube V1, phase shifter tube V2, or amplifier tube V3 (figs. 12 and 13).	Check and replace (par. 42).
		Defective crystal	Try a known good crystal.
		Defective switch S4	Replace switch S4.
5	No voltmeter reading for one particular position of FREQUENCY RANGE KILOCYCLES switch.	Coil L1 or L2 open, or capacitor C6 shorted (fig. 12).	Check and replace (par. 59).
		Defective switch S3	Check and replace.
6	No reading or incorrect voltmeter reading for one or various positions of DRIVE VOLTAGE switch.	Defective drive voltage resistors R5 through R11 (fig. 12).	Check and replace resistors (par 57).
		Defective switch S1	Replace switch S1.
7	No increase in voltmeter reading with increase of GAIN control.	Defective potentiometer R13 (fig. 12).	Check and replace.
8	No change of voltmeter reading with A–R switch in A position and rotation of LOAD CAPACITY control.	Defective capacitor C3 (fig. 12)	Check and replace (par. 58).
		Defective A–R switch	Check and replace (par. 58).
9	No reading or incorrect ohmmeter reading with element in OHMMETER socket for all positions of SELECTOR switch.	Defective OHMMETER ZERO ADJUST potentiometer R20 (fig. 13).	Check and replace.
		Defective microswitch S5 (fig. 13)	Check and replace.
		Defective OHMMETER socket X8 (fig. 13).	Replace socket.
		Defective switch S4	Replace switch S4.
10	No reading or incorrect ohmmeter reading with element in OHMMETER socket and SELECTOR switch in Rx1 position.	Defective resistor R29 or potentiometer R30 (fig. 13).	Check and replace (pars. 57 and 63).
11	No reading or incorrect ohmmeter reading with element in OHMMETER socket and SELECTOR switch in Rx10 position.	Defective resistor R27 or potentiometer R28 (fig. 13).	Check and replace (pars. 57 and 63).
12	Incorrect or no ohmmeter reading with element in OHMMETER socket in Rx100 position.	Defective resistor R25 or potentiometer R26 (fig. 13).	Check and replace (pars. 57 and 63).

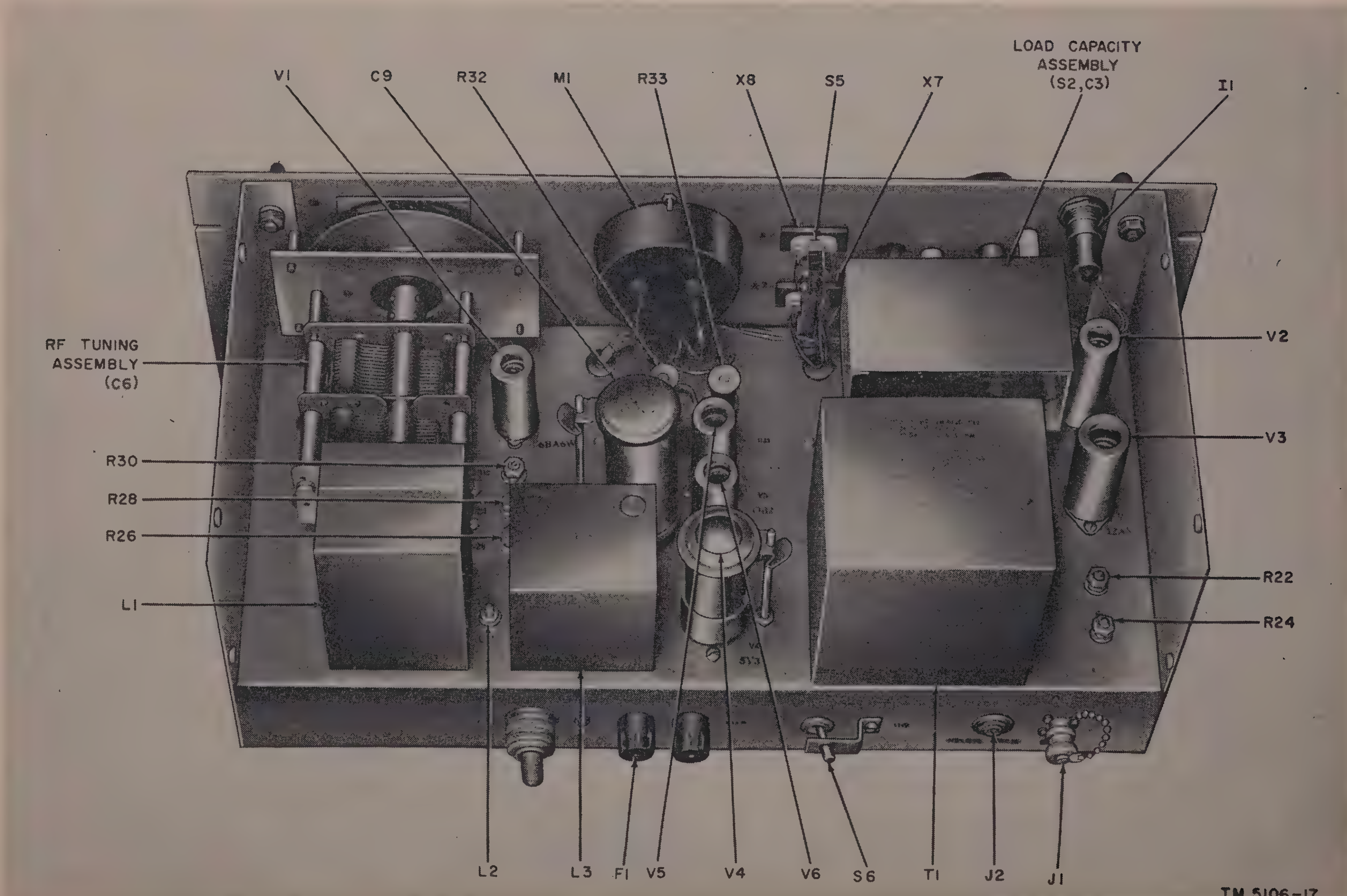


Figure 15. Crystal test set, top rear view, location of parts.

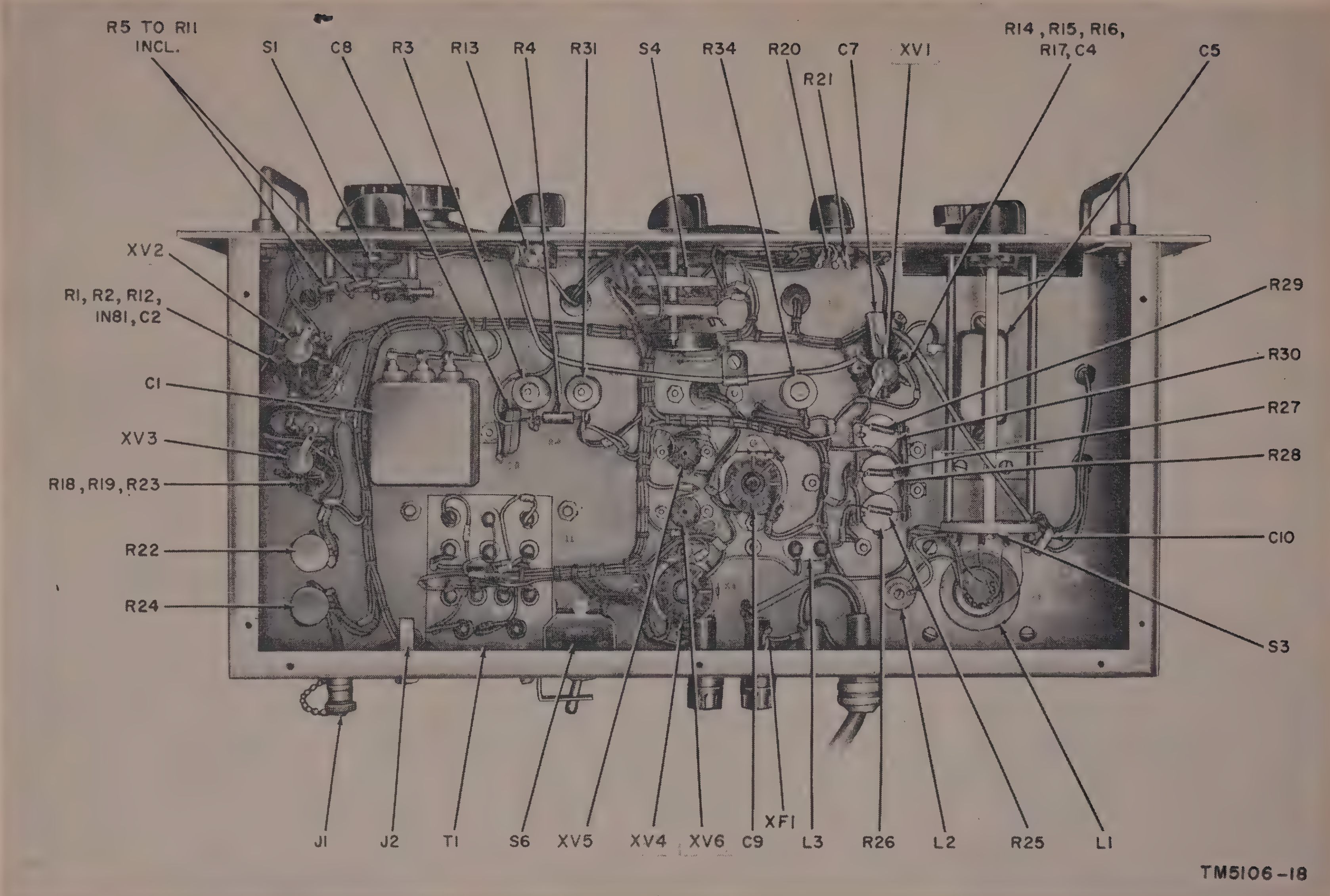
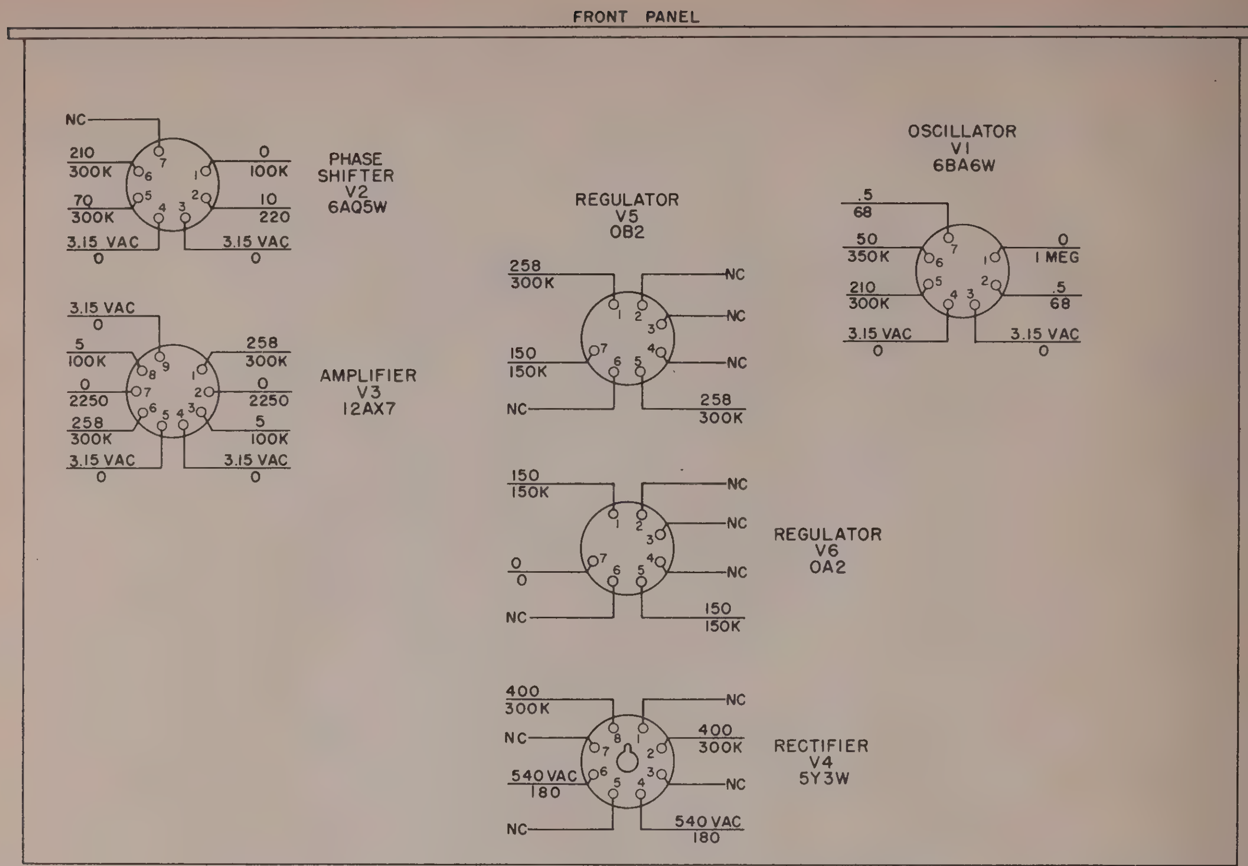


Figure 16. Crystal test set, bottom view, location of parts.



NOTES:

1. LINE VOLTAGE 115 VOLTS AC.
2. ALL SWITCHES AT MAXIMUM COUNTERCLOCKWISE POSITION EXCEPT SELECTOR AT OPERATE.
3. LOAD CAPACITY AT 0 AND TUNING AT 10 KC.
4. ALL MEASUREMENTS BETWEEN INDICATED POINTS AND CHASSIS.
5. USE 20,000 OHM-PER-VOLT METER FOR DC VOLTAGE MEASUREMENTS.
6. VOLTAGE READINGS ABOVE LINE IN D.C. UNLESS OTHERWISE NOTED.
7. RESISTANCE READINGS BELOW LINE IN OHMS UNLESS OTHERWISE NOTED.
8. NC = NO CONNECTION

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Figure 17. Crystal test set, voltage and resistance diagram.

56. Troubleshooting Techniques

a. Test the resistors with a multimeter. The meter indication in ohms must be within the tolerances indicated on the resistor.

b. Test the capacitors for shorts by checking the continuity with the multimeter.

c. Test all tubes with a tube tester or by substitution method (par. 42).

d. Test the coils for dc resistance with an ohmmeter. The allowable tolerance of the values given in the following chart is ±10 percent. Disconnect the equipment from the power source before performing this test.

Transformer or coil	Terminals	Dc ohms
T1	1–2	1.6
	3–4	1.6
	5–6	Negligible
	7–9	Negligible
	10–11	180
	11–12	180
L1	1–7	1.7
	2–7	8.5
	3–7	10
	4–7	65
L2	1–2	2.6
L3	1–2	180

57. Replacement of Parts

Note. Resistors R5, R6, R7, R8, R9, R10, and R11, used in the drive voltage circuit, and resistors R25, R27, and R29, used in the ohmmeter circuit, are precision parts. If even slightly different values of replacement resistors are used, calibration of the crystal test set will be inaccurate.

a. The components of the crystal test set are easily reached and replaced. The sockets, capacitors, filter chokes, and inductors are mounted securely to the chassis with hexagonal nuts and Phillips-head screws. The power transformer is bolted to the chassis.

b. Carefully mark the wires that are connected to the switch wafer with tags to avoid misconnection when the new switch is installed. Follow this practice whenever replacement requires the disconnection of numerous wires. Refer to the wiring diagram (fig. 22).

58. Disassembly and Reassembly of Load Capacity Assembly

Caution: Do not disassemble the load capacity assembly unless it is necessary to replace capacitor C3 or A–R switch S2. If the calibration of capacitor C3 is disturbed during disassembly, recalibrate it after reassembly according to the procedure given in paragraph 61.

a. Disassembly. To disassemble the load capacity assembly (fig. 15), proceed as follows:

(1) Turn the A–R switch to A (fig. 5). Loosen the setscrew that secures the A–R switch knob and remove the knob.

(2) Turn the LOAD CAPACITY knob fully clockwise to mesh the capacitor plates.

(3) Loosen the two setscrews that secure the large LOAD CAPACITY dial and knob in place. These screws are located on the circumference of the large knob.

(4) Remove the small knob and the large knob with the dial from the panel.

Caution: Be careful not to bend the friction drive mechanism when removing these knobs.

(5) Tag and unsolder the wire from the load capacity assembly to CRYSTAL socket X7 at the socket (fig. 15).

(6) Tag and unsolder the wire from the load capacity assembly to DRIVE VOLTAGE switch S1 at the switch.

(7) Remove the three flat head screws, on the front panel (fig. 5), that secure the load capacity assembly to the rear of the panel through three ceramic spacers; then remove the load capacity assembly and spacers.

(8) Remove the hexagonal nut at the front of the load capacity assembly, which secures the A–R switch S2 in place, and remove the two roundhead screws, at the bottom load capacity box, which holds capacitor C3 in place (fig. 15). Remove both these parts from the box.

(9) Tag and unsolder the leads between these two parts. Note how the leads are run to insure correct replacement.

b. Reassembly. To reassemble the load capacity assembly (fig. 15), proceed as follows:

(1) Resolder the connections between loading capacitor C3 and A–R switch S2. Replace the leads in their original positions.

(2) Insert these two parts into the load capacity box and secure load capacitor C3 with two roundhead screws through the bottom of the box, and secure A–R switch S2 with the hexagonal nut at the front of the box.

(3) Mount the load capacity assembly on the rear of the panel with three ceramic spacers and secure it with three flathead screws from the front of the panel.

(4) Resolder the wires from the load capacity assembly to CRYSTAL socket X7 and DRIVE VOLTAGE switch S1. Replace the leads in their original positions.

(5) Engage the driven plate of the large LOAD CAPACITY knob and dial into the friction drive plates of the small knob. Be very careful with this mechanism.

(6) Insert this assembly on the front panel (fig. 5).

(7) Rotate the large knob until the dial setting is the same as before disassembly and secure the large knob in place with the two setscrews.

(8) Replace the A–R switch knob in its previous position and tighten the setscrew that holds it in place.

(9) Recalibrate capacitor C3 according to the procedure given in paragraph 61.

59. Disassembly and Reassembly of Rf Tuning Assembly

Caution: Do not disassemble the rf tuning assembly unless it is necessary to replace capacitor C6. Be careful during reassembly to prevent a loss of calibration.

a. Disassembly. To disassemble the rf tuning assembly (fig. 15), proceed as follows:

(1) Set the TUNING dial so that the vertical line, on the dial, lines up with the window hairline. Capacitor C6 will then be in a closed position (plates fully meshed).

(2) Tag and unsolder the leads to the tuning capacitor C6.

(3) Loosen the setscrew that holds the TUNING knob; then remove the knob.

(4) Remove the four flathead screws, on the front of the panel (fig. 5) that hold the rf tuning assembly to the rear of the panel through four spacers; then remove the assembly and spacers (fig. 15).

(5) Remove the three screws that hold the dial to the friction drive; then remove the dial from the friction drive.

(6) Loosen the two setscrews that secure the coupling (between the friction drive and the capacitor) to the capacitor.

(7) Remove the four screws that hold the friction drive to the plate; then remove the friction drive and coupling.

(8) Remove the four screws that secure the plate to capacitor C6 through four spacers; then remove the plate and spacers.

b. Reassembly. To reassemble the rf tuning assembly (fig. 15), proceed as follows:

(1) Attach the plate, four spacers, and capacitor C6 together with the four flathead screws.

(2) Attach the friction drive and coupling to the plate with four roundhead screws and lockwashers.

(3) Secure capacitor C6 to the coupling with the two setscrews.

(4) Set capacitor C6 in the closed position (plate fully meshed).

(5) Attach the dial to the friction drive with three roundhead screws so that the vertical line is at the top. It may be necessary to readjust the coupling between the friction drive and the capacitor.

(6) Attach the rf tuning assembly to the panel with four spacers and four flathead screws.

(7) Attach the TUNING knob to the rf tuning assembly and secure the setscrew.

(8) Resolder the connections to capacitor C6.

(9) With capacitor C6 in the closed position (plates fully meshed), check the alinement of the left vertical line on the dial with the hairline on the window.

(10) Correct any slight discrepancy by loosening the two screws that hold the window to the panel; adjust the window *exactly* over the vertical line of the dial; and secure the window in place with the two screws.

60. Test Equipment Required for Calibration and Alinement

The following test equipment is required for calibration and alinement of the crystal test set.

Test equipment	Common name	Technical manual
Q-Meter TS-617A/U	Q-Meter	TM 11-2635
Frequency Meter AN/URM-79.	Frequency meter	TM 11-5094
Variable capacitance standard Sig C stock No. 3F2470 (p/o Laboratory Standards AN/URM-2).	Precision capacitor.	
Resistance Bridge ZM-4/U.	Bridge	TM 11-2019
Electronic Multimeter TS-505/U.	Electronic multimeter.	TM 11-5511
Decade Resistor TS-679/U.	Decade resistor	TM 11-5520

61. Readjustment and Calibration of Capacitor C3

When capacitor C3 or A-R switch S2 is replaced, an adjustment is necessary to aline the LOAD CAPACITY dial to 0 with capacitor C3 set at its minimum value (plates fully extended). It is then necessary to determine this value of minimum load capacitance in $\mu\mu$f. The equipment (par. 60) is connected for this procedure as shown in figure 18. The frequency meter is used to stabilize the frequency of the Q-meter; the standard inductance coil is used to tune the Q-meter to resonance. The SELECTOR switch of the crystal test must be in the OFF position during the entire procedure given below.

a. Set up the circuit shown in figure 18 as follows:

(1) Use No. 12 AWG solid copper wire supported on 2-inch centers to connect the frequency meter, the standard inductance coil, and the precision capacitor to the Q-meter.

(2) Connect a wire from the unused stator terminal of capacitor C3 to the HIGH terminal of the precision capacitor. This wire should be stiff, bare, located as far as possible from anything grounded, and not smaller than No. 16 AWG bare copper tinned wire. The same physical relationship should exist for every measurement with the wire connection as short as possible and kept away from ground. Arch the wire about 3 inches from ground as soon as it leaves the terminal of capacitor C3.

(3) Connect a stiff No. 16 AWG wire from the shield of capacitor C3 through the shaft of the capacitor, to the ground terminal of the precision capacitor.

Caution: It is more important to keep the wires in the same physical relationship to each other and ground, when the capacitance measurement is made, than to shorten the wires.

(4) Connect the ground terminal of the precision capacitor to a good ground, such as a water pipe, a steam pipe, or a BX electrical cable that is well-grounded. Errors caused by capacitance between the equipment being tested and the personnel performing the testing will thus be reduced.

b. Set the LOAD CAPACITY dial to 0 (aline it with the zero on the vernier scale). Capacitor C3 will be in a position of approximate minimum capacitance (plate fully extended).

c. Adjust the precision capacitor to 50 $\mu\mu$f.

d. Adjust the Q-meter to resonate at 400 kc. This condition is indicated by the maximum (peak) deflection of the Q-meter galvanometer. Note the position of the galvanometer indicator.

e. Add 10 $\mu\mu$f of capacitance to the resonant circuit by means of the capacitance dial on the Q-meter. This action will throw the circuit off resonance and the Q-meter galvanometer deflection will be less than the previously obtained maximum (*d* above).

f. Adjust the LOAD CAPACITY dial until a position as close as possible to the previous condition of resonance is obtained. This will be indicated by the increased deflection of the galvanometer indicator on the Q-meter to almost the previous maximum but not quite reaching it.

Note. If the previous maximum value of galvanometer indication is reached, not enough capacitance was added to the resonant circuit (*e* above) and also, the minimum value of the load capacitance has not yet been obtained. It will then be necessary to add additional capacitance (by means of the capacitance dial to the Q-meter) and retune the LOAD CAPACITY dial to produce a deflection of the galvanometer on the Q-meter that approaches resonance but not quite reaching it.

g. When the value of minimum capacitance has been obtained, carefully loosen the two setscrews on the circumference of the large LOAD CAPACITY dial; adjust this dial so that the zero lines up *exactly* with the zero on the vernier scale; then

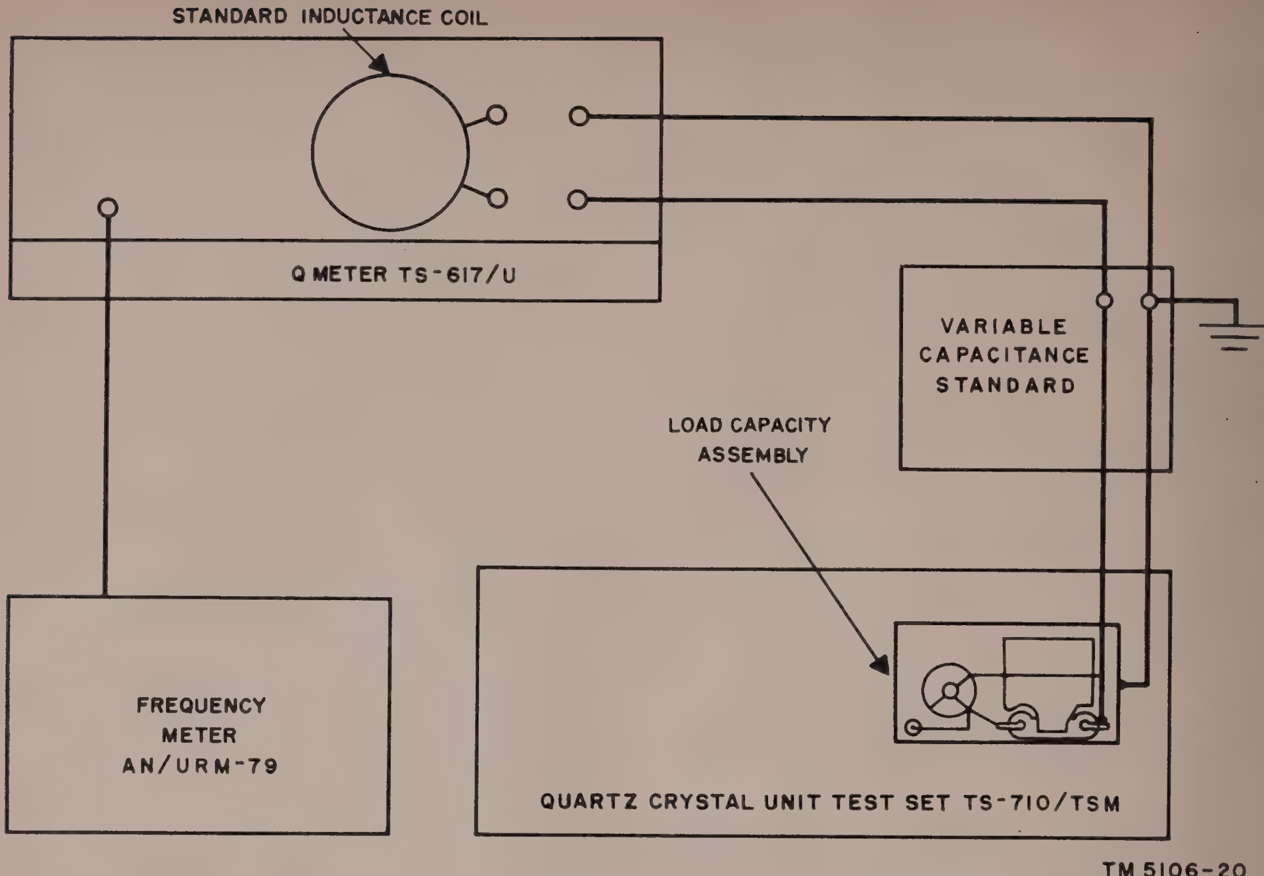


Figure 18. Test circuit for readjustment and calibration of capacitor C3.

tighten the setscrews and lock the dial in place.

h. Rotate the dial to the other end and then back to zero. Check to see if the deflection of the galvanometer on the Q-meter is at maximum reading when the LOAD CAPACITY dial is set at zero. The minimum of load capacitance has now been obtained.

i. To find the value of this minimum, retune the Q-meter to resonance indicated by maximum deflection of the galvanometer. Note the setting of the precision capacitor.

j. Remove the wire that is connected to the stator terminal of capacitor C3. To prevent any change in capacitance, it is important to keep this wire as close as possible to its previous position.

k. Adjust the precision capacitor to obtain resonance again.

l. The difference between the two settings of the precision capacitor is the value of minimum capacitance of capacitor C3.

m. Repeat this process twice to make sure that the *exact* value of minimum capacitance has been obtained.

n. Prepare a load capacitance chart as described in paragraph 67.

62. Calibration of Meter M1 as a Voltmeter

a. Adjust the crystal test set as follows:

(1) Insert a calibration resistor of any desired value in the CRYSTAL socket.

(2) Set the A–R switch to the R position.

(3) Set the DRIVE VOLTAGE switch to the 0 position.

(4) Set the GAIN control to the maximum counterclockwise position.

(5) Set the SELECTOR switch to the OPERATE position. Allow 15 minutes for the equipment to warm up.

(6) If necessary, readjust potentiometer R24 to obtain a zero reading on meter M1.

(7) Set the DRIVE VOLTAGE switch and the GAIN controls to the lowest settings for a midscale reading on meter M1.

b. With an *external* vacuum-tube voltmeter, measure the voltage between each side of the CRYSTAL socket and chassis ground. The dif-

ference between these two readings should be the same as the voltage reading of meter M1 within ±10 percent.

c. If there is a discrepancy greater than 10 percent, adjust potentiometer R22 until the reading of meter M1 is within 10 percent.

d. Check the accuracy of meter M1 on the other two scales as instructed in *a* through *c* above. With the DRIVE VOLTAGE switch in either the 0.25, 2.5, or 25 position, the voltage across the CRYSTAL socket is indicated on the 25-volt scale of meter M1. With the DRIVE VOLTAGE switch in either the 0.5 or 5.0 position, the voltage across the CRYSTAL socket is indicated on the 5-volt scale of meter M1. With the DRIVE VOLTAGE switch in either the 1.0 and 10 position, the voltage across the CRYSTAL socket is indicated on the 10-volt scale of meter M1.

Note. Potentiometer R22 must be adjusted until the voltage indicated on meter M1 is within ±10 percent on all scales.

63. Calibration of Meter M1 as an Ohmmeter

a. Initial Settings of Test Set.

(1) Set the A–R switch to the R position.

(2) Set the DRIVE VOLTAGE switch to the O position.

(3) Set the GAIN control to the maximum counterclockwise position.

(4) Connect Decade Resistor TS–679/U to the OHMMETER socket.

(5) Set the SELECTOR switch to the OPERATE position. Allow 15 minutes for the equipment to warm up.

b. Calibrating Rx1 Range.

(1) Adjust the crystal test set as instructed in *a* above.

(2) Adjust the decade resistor to 1,000 ohms.

(3) Set the SELECTOR switch to the Rx1 position.

(4) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(5) Push the actuator pin (fig. 5) located below the OHMMETER socket. Meter M1 should read 1,000 ±5 percent on the ohms scale. If it does not, adjust potentiometer R30 (fig. 15) until the meter reads 1,000.

c. Calibrating Rx10 Range.

(1) Adjust the crystal test set as instructed in *a* above.

(2) Adjust the decade resistor to 10,000 ohms.

(3) Set the SELECTOR switch to the Rx10 position.

(4) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(5) Push the actuator pin (fig. 5) located below the OHMMETER socket. Meter M1 should read 1,000 ±5 percent on the ohms scale. If it does not, adjust potentiometer R28 (fig. 15) until the meter reads 1,000.

d. Calibrating Rx100 Range.

(1) Adjust the crystal test set as instructed in *a* above.

(2) Adjust the decade resistor to 100,000 ohms.

(3) Set the SELECTOR switch to the Rx100 position.

(4) Adjust the OHMMETER ZERO ADJUST control until the meter reads 0 ohm.

(5) Push the actuator pin (fig. 5) located below the OHMMETER socket. Meter M1 should read 1,000±5 percent on the ohms scale. If it does not, adjust potentiometer R26 (fig. 15) until the meter reads 1,000.

64. Readjustment of Coil L2

a. Set the crystal test set as follows:

(1) Connect Decade Resistor TS–679/U, adjusted to 4,500 ohms, to the CRYSTAL socket.

(2) Set the A–R switch to the R position.

(3) Set the FREQUENCY RANGE KILOCYCLES switch to the 450–1100 position.

(4) Set the SELECTOR switch to the OPERATE position. Allow 15 minutes for the equipment to warm up.

(5) Set the DRIVE VOLTAGE and GAIN controls to the lowest settings for a midscale reading on the meter.

(6) Set the TUNING dial so that the window hairline cuts the engraved numeral 1100 between 11 and 00.

b. Connect the crystal test set to the frequency meter through the rf output cable. Set the frequency meter to generate a voltage at a frequency of 1,100 kc.

c. Adjust the tuning slug of coil L2 until a zero beat is heard from the frequency meter speaker.

d. Readjust the decade resistor to 11,000 ohms.

e. Set the frequency meter to generate a 450-kc signal and adjust the TUNING dial until a zero beat is obtained.

f. Compare the TUNING dial window hairline with the 450 engraving on the dial. If necessary, readjust the slug of coil L2 until the zero beats of the 450-kc signal occurs as near the dial engravings as possible. The dial accuracy shall be within ±2 percent.

g. Repeat the procedure for the 1,100-kc check. Readjust coil L2 slug if necessary.

Section IV. FINAL TESTING

65. General

This section is intended as a guide to be used in determining the quality of a repaired crystal test set. The minimum test requirements outlined in paragraphs 67 through 69 below must be performed by trained maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements (pars. 67–69) will operate satisfactorily.

66. Test Equipment Required for Final Testing

Items of test equipment that are required for final testing are listed in paragraph 60. Use only these equipments or their equivalents.

67. Checking Calibration Chart

a. If capacitor C3 is replaced, it may be necessary to replot the crystal load capacitance calibration chart (fig. 6).

b. The calibration chart is prepared by the equipment manufacturer from data obtained by measuring the actual capacitance value of capacitor C3 (within ±0.1 $\mu\mu$f) for various settings of the LOAD CAPACITY dial. Plotting points are taken at every dial division from 0 to 12, at every two divisions from 12 to 30, and at every five dial divisions from 30 to 100. If the chart is being replotted, use the value of minimum capacitance obtained in paragraph 61 for the zero setting of the LOAD CAPACITY dial.

c. Connect the equipment as shown in figure 18. The stability of Q-Meter TS–617A/U must be very good. Frequency stability at 400 kc is accomplished by use of the frequency meter. The wiring between units must be No. 12 AWG solid copper wire supported on 2-inch centers. The Q-meter is tuned to resonance by using a standard inductance with the precision capacitor set at 200 $\mu\mu$f and the LOAD CAPACITY dial set at zero.

d. Move the LOAD CAPACITY dial up one division. Retune the precision capacitor to resonance. The difference in reading of the precision capacitor is the value of capacitance added by moving the dial one division. Add this value to the minimum capacitance and record the total.

e. Move the LOAD CAPACITY dial to the second division. Retune the precision capacitor to resonance. The difference in reading of the precision capacitor is again the value of capacitance added by moving the dial up one more division. Add this value to the *value previously obtained in d above* and record the total.

f. Continue this process every division from 3 to 12, every two divisions from 12 to 30 and every five divisions from 30 to 100. Always add the difference in the reading of the precision capacitor to the value of capacitance obtained in the previous step to compute the value of capacitance at that position.

g. Plot the data as shown in figure 6. If capacitor C3 has been replaced, use this chart for future determination of LOAD CAPACITY dial settings. Otherwise check the new data against the calibration chart supplied with the crystal test set. The figures should agree within ±0.2 $\mu\mu$f up to 35 $\mu\mu$f and ±0.5 $\mu\mu$f above 35 $\mu\mu$f. The capacitance range shall be from less than 20 $\mu\mu$f to more than 100 $\mu\mu$f.

68. Oscillation Test

a. Position the crystal test set controls as follows:

(1) Set the DRIVE VOLTAGE switch to the 25 position.

(2) Set the GAIN control to the maximum clockwise position.

(3) Be sure there is no element in the CRYSTAL socket.

(4) Turn the SELECTOR switch to the OPERATE position.

b. Rotate the TUNING knob (which controls capacitor C3) so that the tuning dial rotates through 180° for each position of the FREQUENCY RANGE KILOCYCLES switch. No self-controlled oscillation (voltage) should be indicated on the voltmeter. Should oscillation occur,

eliminate it by adjusting the positions of the grid and plate circuit wires of oscillator tube V1.

69. Performance Test

a. The performance test is designed to determine if the crystal test set is performing within the required limits. This is accomplished by using a crystal with known parameters. These parameters are: the series-resonant frequency (F_s), the series-resonant resistance (R), the antiresonant frequency (F_a), the antiresonant resistance (R_e), and the load capacitance (C_o).

b. Operate the crystal test set (par. 17, 18, 19, or 20) to determine the five parameters indicated in *a* above. The values obtained from the crystal test set compared to the known parameters of the crystal must agree within 10 percent for the resistance values, 0.001 percent for the frequency values, 0.5 $\mu\mu$f for the load capacitance value of 35 $\mu\mu$f and above, and 0.2 percent for the load capacitance value below 35 $\mu\mu$f.

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

70. Disassembly

The following instructions are recommended for use as a general guide for preparing the crystal test set for transportation and storage.

a. Remove the rf pickup cable assembly (Cord CG–433A/U) that is connected to the OUTPUT jack.

b. Remove all adapters, calibration potentiometers, or calibration resistors from the panel of the crystal test set. Place these parts in the accessory box.

c. Check the contents of the accessory box to see that it is complete.

d. Check the equipment against the table of components (par. 5) to see that it is complete.

71. Repacking for Shipment or Limited Storage

Figure 4 illustrates one method of repacking the equipment. Specific directions for packing the crystal test set are as follows:

a. Cushion the set on all surfaces with cells or pads fabricated of corrugated fiberboard. Place desiccant together with the literature, within a close-fitting, slotted, corrugated fiberboard box. Seal the entire closure with gummed tape and blunt all corners of the box.

b. Place the boxed set within a moisture-vaporproofed barrier, and heat-seal the closure. Place the moisture-vaporproof set within a second close-fitting, slotted, corrugated fiberboard box and seal the entire closure with water-resistant tape or adhesive.

c. Overwrap the boxed set in waterproof barrier material. Completely seal all joints, seams, and closures with an approved adhesive (or other suitable seal as moisture-resistant as the barrier).

d. Materials used in the packing described in *a*, *b*, and *c* above must comply with applicable requirements. Proceed as follows:

(1) Place the equipment, packaged as described above, within a nailed wooden box lined inside with a 2-inch thickness of excelsior. Do *not* line the shipping container with a waterproof bag.

(2) Strap the shipping container in accordance with approved specifications.

(3) Signal Corps depots must mark interior packages and shipping containers in accordance with current special regulations.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

72. General

The demolition procedures outlined in paragraph 73 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the local commander.

73. Methods of Destruction

Use any or all of the methods given below, depending on which tools or explosives are available.

a. Smash. Smash the controls, tubes, coils, switches, capacitors, transformers, and meter; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut the power and rf output cords; use axes, handaxes, or machetes.

c. Burn. Burn cords and instruction book; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

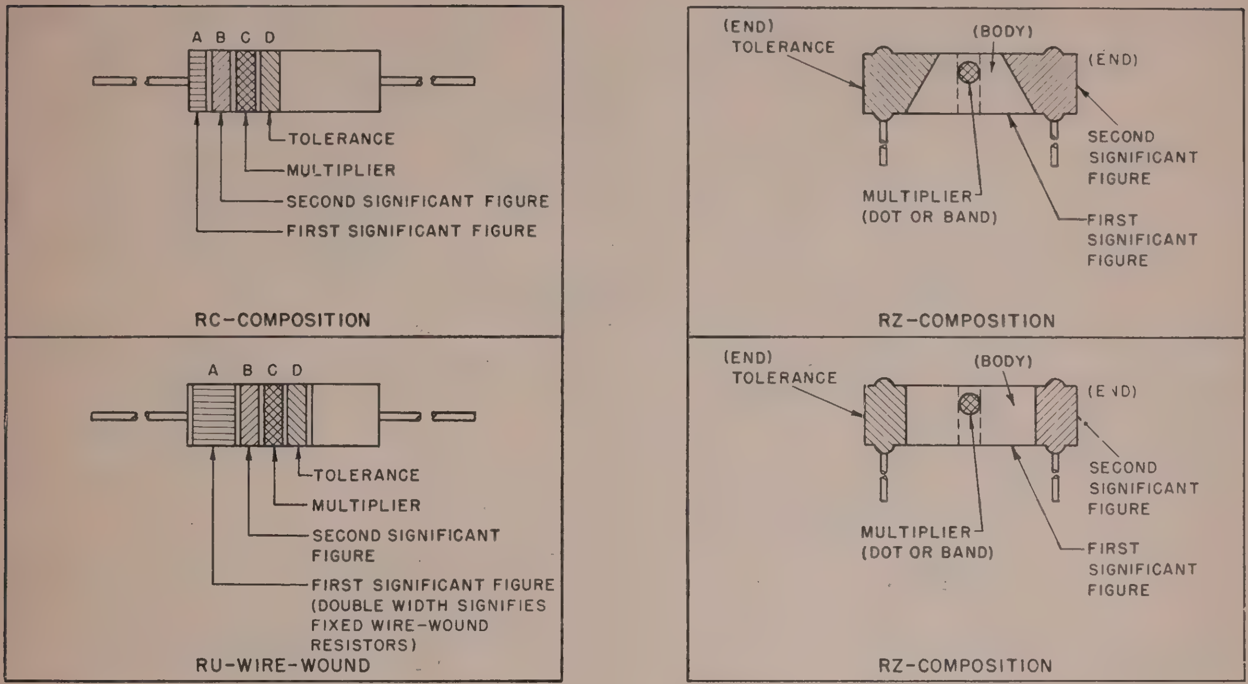
d. Bend. Bend the panels and chassis.

e. Explode. If explosives are necessary, use firearms, grenades, or TNT.

f. Dispose. Bury or scatter the destroyed parts in slit trenches, foxholes, or throw them into streams.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED) | RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

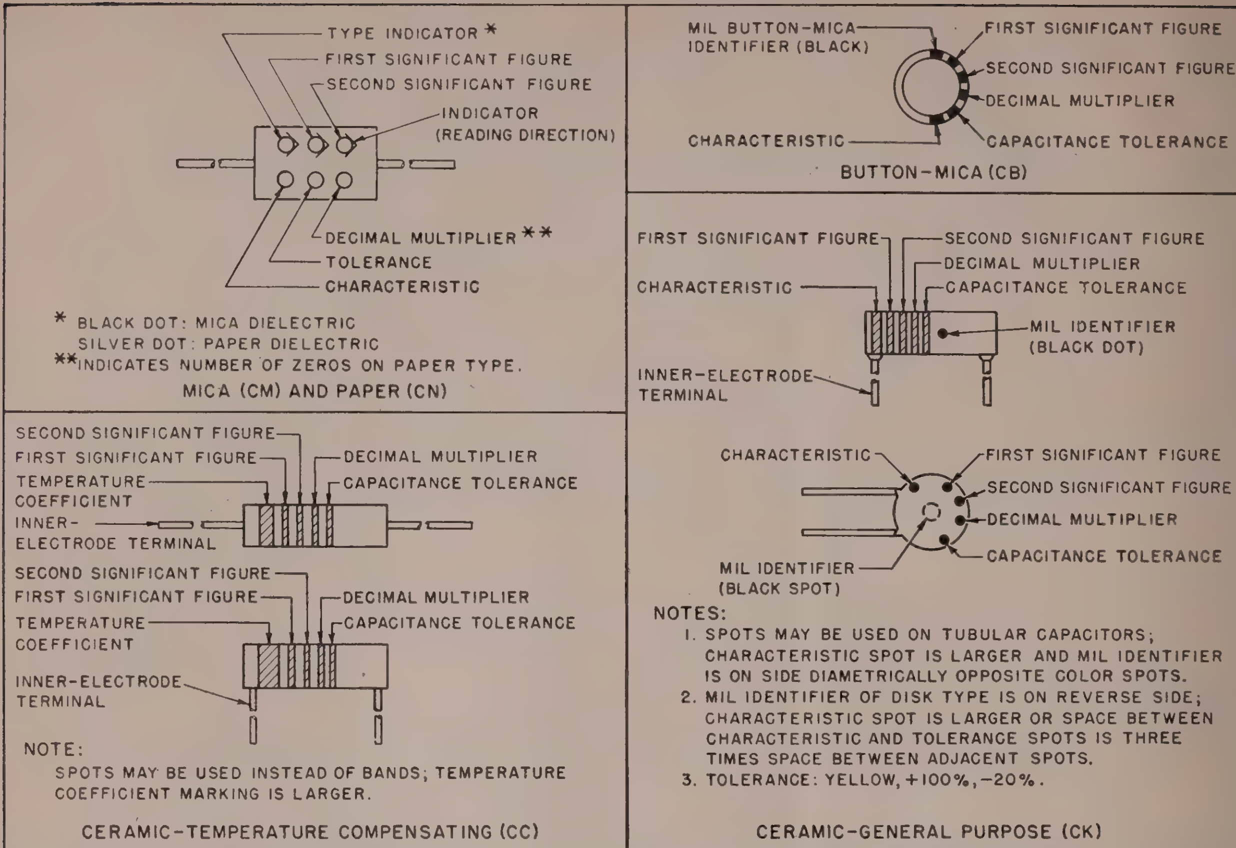
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R/

Figure 19. MIL-STD resistor color codes.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC [1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC OVER 10UUF	CC 10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		−30
RED	2	100	2	C	H		X	2		2	2		−80
ORANGE	3	1,000	3	D	J	D			30				−150
YELLOW	4	10,000	4	E	P								−220
GREEN	5		5	F	R						5	0.5	−330
BLUE	6		6		S								−470
PURPLE (VIOLET)	7		7		T	W							−750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	−330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

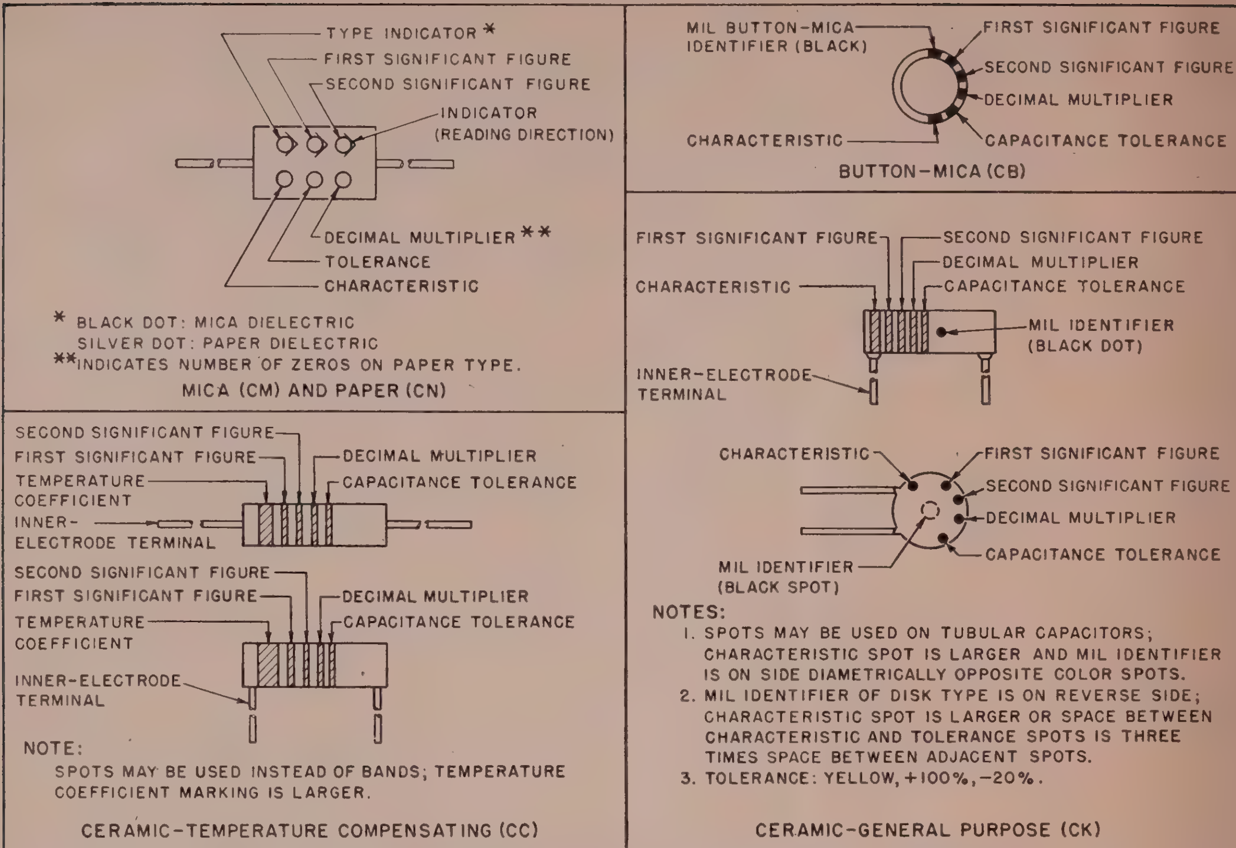
1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 20. MIL-STD capacitor color codes

15-530
UUF
C6
TUNIN
L

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



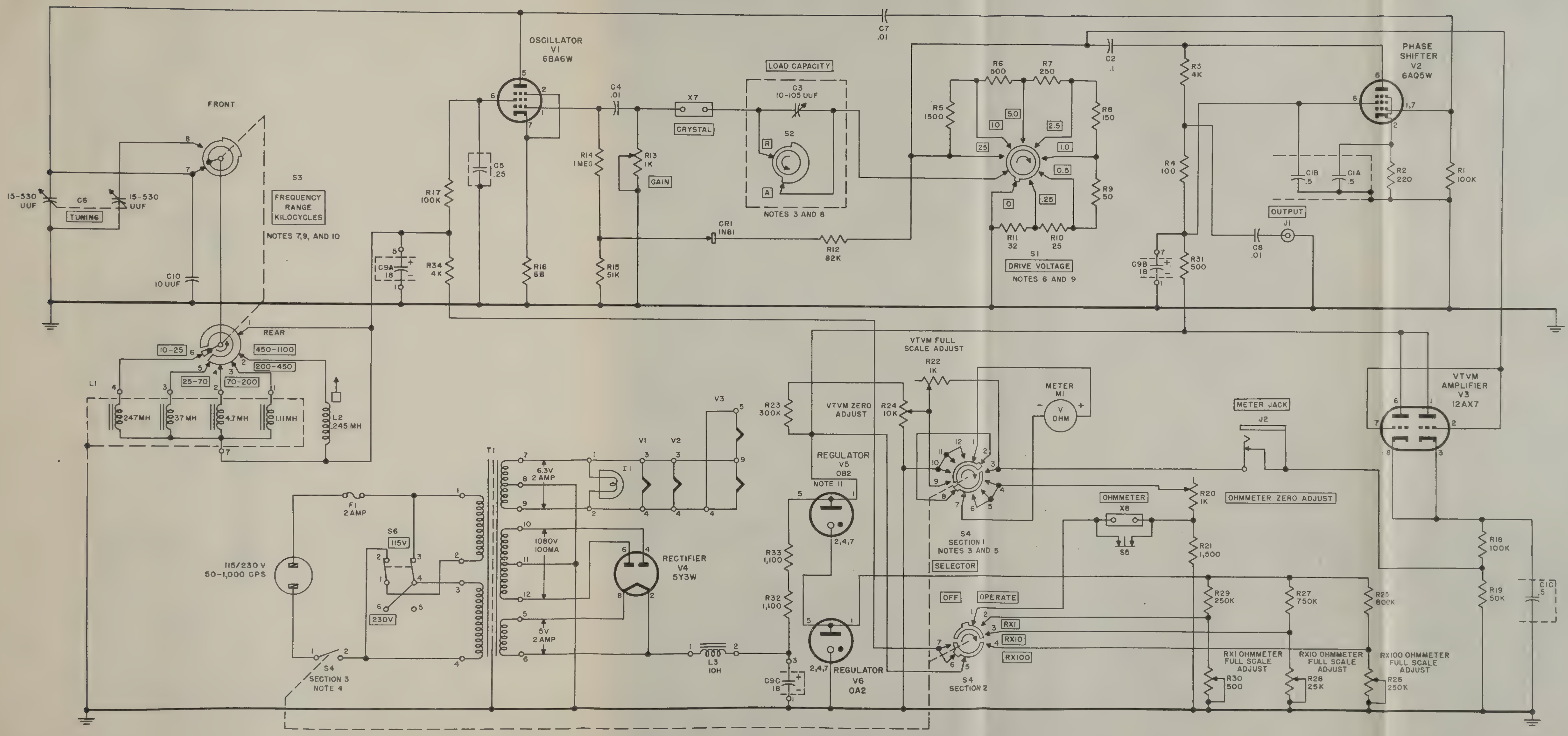
CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC OVER 10UUF	CC 10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		−30
RED	2	100	2	C	H		X	2		2	2		−80
ORANGE	3	1,000	3	D	J	D			30				−150
YELLOW	4	10,000	4	E	P								−220
GREEN	5		5	F	R						5	0.5	−330
BLUE	6		6		S								−470
PURPLE (VIOLET)	7		7		T	W							−750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	−330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 20. MIL-STD capacitor color codes

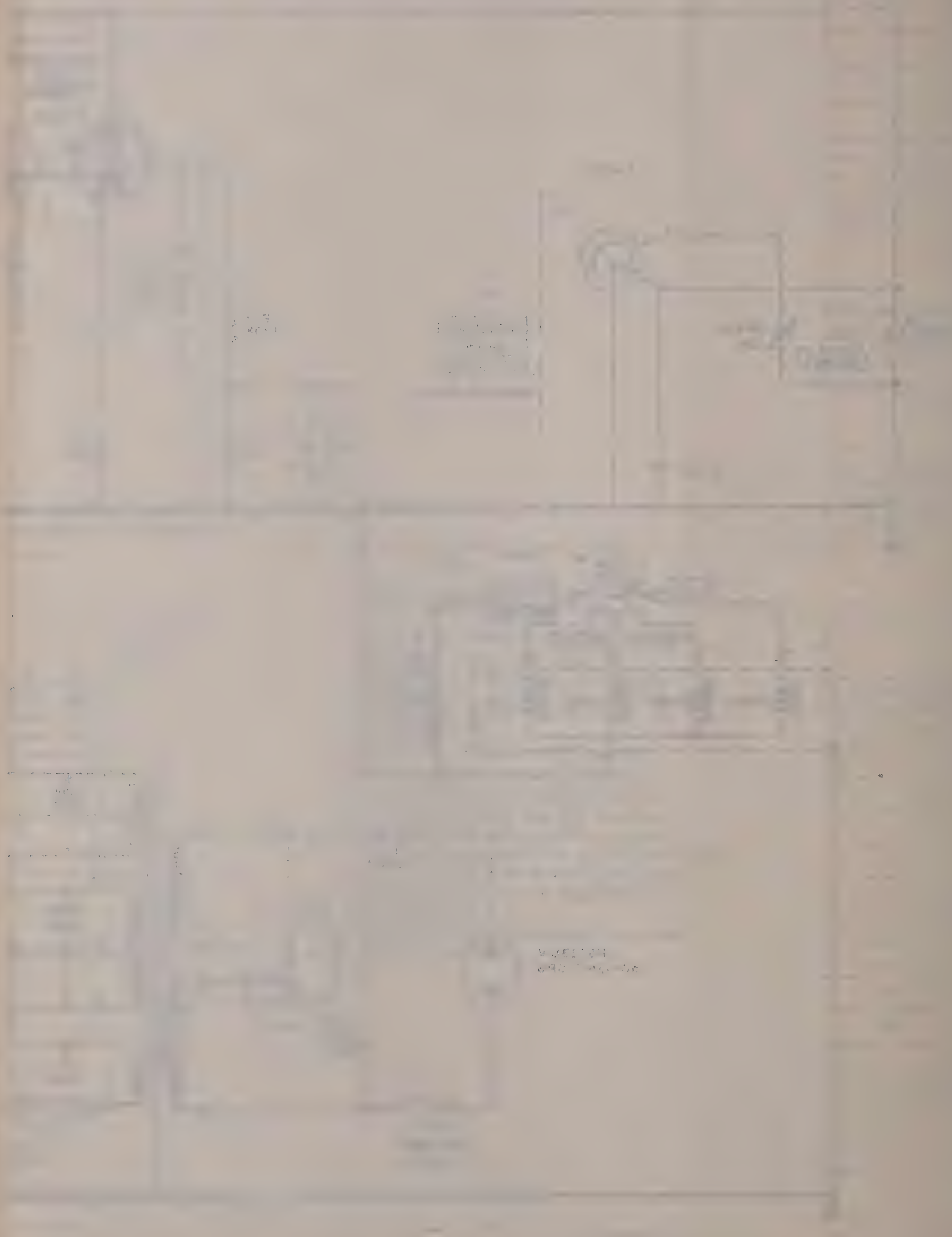


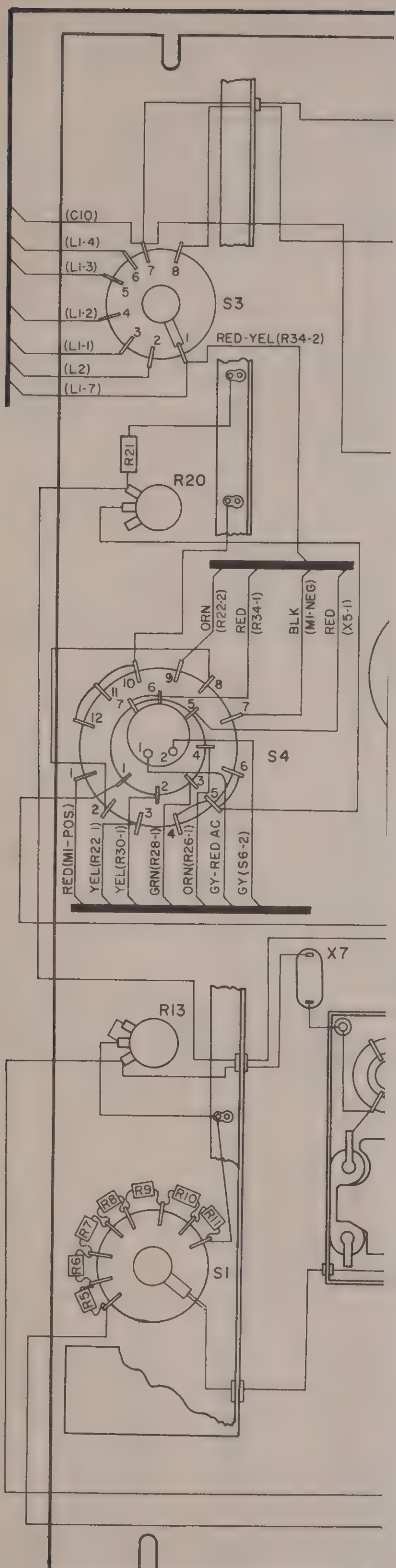
NOTES

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF.
2. $\boxed{}$ INDICATES EQUIPMENT MARKING.
3. SWITCHES S2 AND S4 ARE SHOWN AS VIEWED FROM CONTROL KNOB END. SECTIONS DESIGNATED NO.1 ARE NEAREST THE KNOB END.
4. SECTION 3 OF WAFER SWITCH S4 IS THE AC TOGGLE SWITCH.
5. SWITCH S4 IS SHOWN IN THE OFF POSITION.
6. SWITCH S1 IS SHOWN IN THE 0 POSITION.
7. SWITCH S3 IS SHOWN IN THE 10-25 POSITION.
8. SWITCH S2 IS SHOWN IN THE R POSITION.
9. SWITCHES S1 AND S3 ARE SHOWN AS VIEWED FROM THE END OPPOSITE THE CONTROL KNOB END.
10. FRONT CONTACTS 7 AND 8 ARE CLOSED WHEN SWITCH S3 IS IN POSITIONS 200-450 AND 450-1100 ONLY.
11. REMOVAL OF TUBE V5 DISCONNECTS VOLTAGE FROM THE LOAD.

TM 5106-23

Figure 21. Quartz Crystal Unit Test Set TS-710/TSM, schematic diagram.





(C10)
(L1-4)
(L1-3)
(L1-2)
(L1-1)
(L2)
(L1-7)
S3
RED-YEL(R34-2)
R21
R20
ORN (R22-2)
RED (R34-1)
BLK (M1-NEG)
RED (X5-1)
S4
RED(M1-POS.)
YEL(R22 1)
YEL(R30-1)
GRN(R28-1)
ORN(R26-1)
GY-RED AC
GY(S6-2)
X7
R13
R5
R6
R7
R8
R9
R10
R11
S1

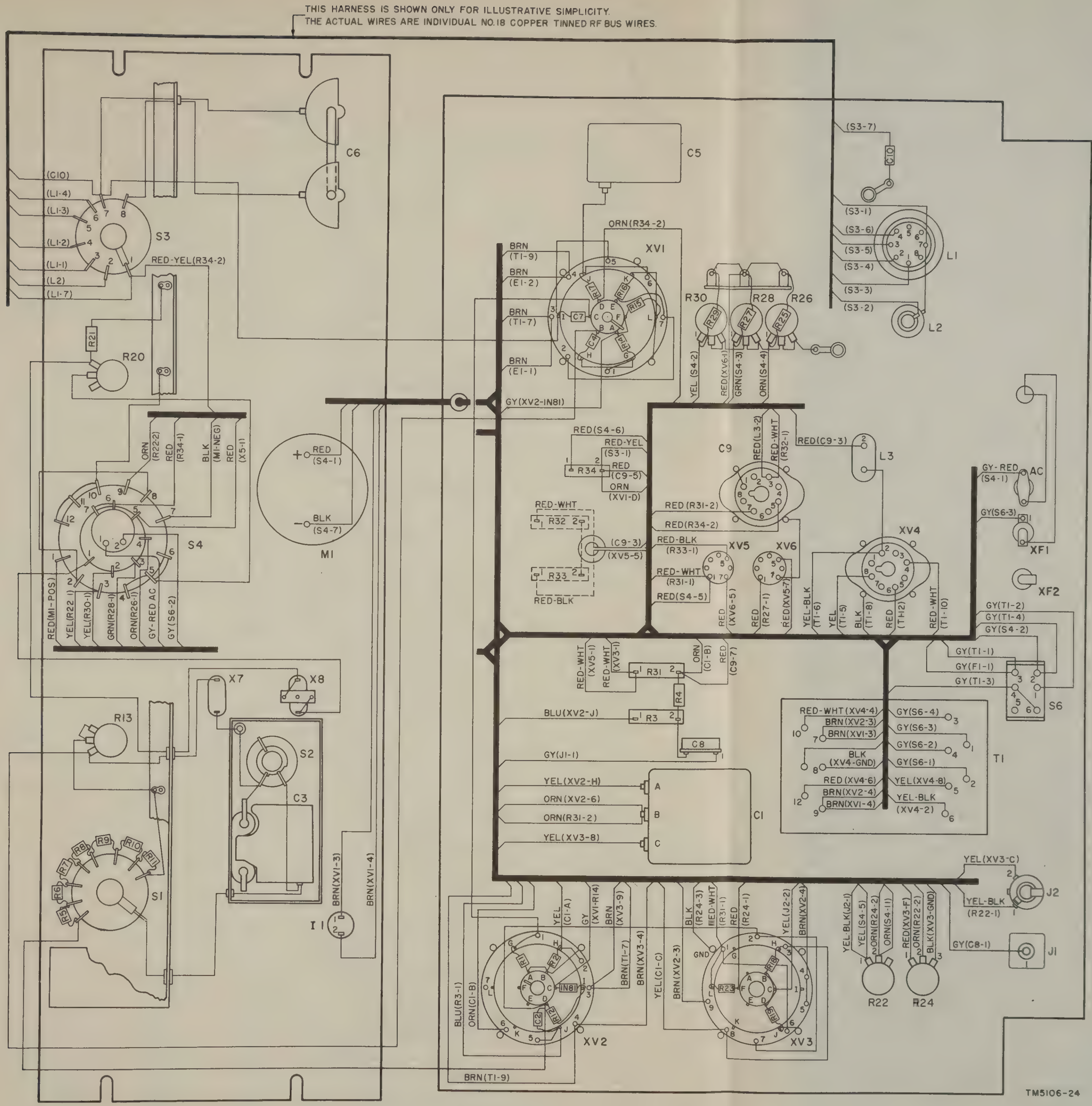


Figure 22. Quartz Crystal Unit Test Set TS–710/TSM, wiring diagram.

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[AG 413.6 (8 Mar 56)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

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Chief of Staff.

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OS Base Comd (5)
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Corps (2)
Tng Div (2)
Ft & Cp (2)
Gen & Br Svc Sch (5) except Sig Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (20)
Trans Terminal Comd (2)
Army Terminals (2)
OS Sup Agencies (2)
Sig Fld Maint Shops (3)
Sig Lab (5)
Mil Dist (1)
Units organized under following TOE's:
11–7R, Sig Co, Inf Div (2)
11–16R, Hq & Hq Co, Sig Bn, Corps or Abn Corps (2)
11–57R, Armed Sig Co (2)
11–127R, Sig Rep Co (2)
11–128R, Sig Depot Co (2)
11–500R (AA–AE), Sig Svc Org (2)
11–557C, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy per unit.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1956

TM 11-5106—QUARTZ CRYSTAL UNIT TEST SET TS-710/TSM—1956